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HARVARD UNIVERSITY

LIBRARY OF THE

GRADUATE SCHOOL
OF EDUCATION

TRADE FOUNDATIONS

BASED ON

PRODUCING INDUSTRIES

AGRICULTURAL OCCUPATIONS
MANUFACTURING & MECHANICAL PURSUITS
MINING INDUSTRIES
LUMBERING INDUSTRIES
ELEMENTARY SCHOOLS

Dedicated to

"THE BOY ON THE FENCE"

Upon whose selection and successful pursuit of a vocation depends the welfare of the industrial and political future of the world.

AUTHORS

R. H. RODGERS, *Director of Industrial Arts, Stout Institute, Menomonie, Wisconsin.*

J. I. SOWERS, *Director of Vocational Education, Vincennes, Indiana.*

L. DAY PERRY, *Supervisor of Industrial Work, Joliet, Illinois.*

CHARLES W. SYLVESTER, *Director of Pre-Vocational and Vocational Education, Hammond, Indiana.*

GEORGE M. BRACE, *Director of Industrial Work for Grade and High Schools, St. Paul, Minnesota.*

EARL D. HAY, *Instructor in Industrial Dept., State Normal School, Oshkosh, Wisconsin.*

RAYMOND C. KEOPLE, *Supervisor of Manual Training, Rochester, New York.*

R. S. WHITING, *Architectural Engineer, National Lumber Manufacturers Association, Chicago, Illinois.*

J. E. RAY, *Instructor of Bricklaying, Stout Institute, Menomonie, Wisconsin.*

H. COLIN CAMPBELL, *Director of Editorial Bureau, Portland Cement Association, Chicago, Illinois.*

H. F. GOOD, *Instructor of Gas Engineering, Stout Institute, Menomonie, Wisconsin.*

J. J. RITTER, *Director of Industrial Work, Ft. Wayne, Indiana.*

H. H. HARRISON, *Director of Industrial Work, Marshall, Michigan.*

H. T. PURFIELD, *Instructor of Forge and Foundry Work, Ft. Wayne, Indiana.*

EDWARD E. GREENE, *Instructor of Sheet Metal Work, Arsenal Technical Schools, Indianapolis, Indiana.*

E. C. GRAHAM, *Vocational Director, Evansville, Indiana.*

H. C. MILNES, *Instructor of Machine Shop Work, Stout Institute, Menomonie, Wisconsin.*

R. F. JARVIS, *Instructor of Forging, Stout Institute, Menomonie, Wisconsin.*

R. W. HASTINGS, *Practical Arts Department, Chestnut St. Junior High School, Springfield, Massachusetts.*

R. W. AUSTIN, *Welding Expert, Chicago, Illinois.*

C. S. GOLDSMITH, *Supervisor of Industrial Arts, Carlstadt and Oradell, New Jersey.*

EDWARD F. WORST, *Supervisor of Elementary Manual Training and Construction Work, Chicago, Illinois.*

F. B. MCELROY, *Instructor of Industrial Arts, Washington School, Indianapolis, Indiana.*

RALPH W. POLK, *Director of Vocational Instruction, St. Joseph, Missouri.*

FRANK M. TREAT, *Instructor of Industrial Arts, Indiana University, Bloomington, Indiana.*

Trade Foundations

Based on

Producing Industries

A Pre-Vocational Text-Book

by

Pre-Vocational and Vocational Directors
Instructors, and Tradesmen

With Preface by

T. N. CARVER, *Professor of Political Economy, Harvard University, Cambridge, Massachusetts.*

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PREFACE

Every bad economic situation is due to the fact that things are out of proportion. In order to get a desirable economic result, the factors which have to be combined in order to get that result need to be combined in the right proportions. This rule holds good whether mixing chemicals in a laboratory, mixing feeds for fattening a steer, mixing fertilizers for land, combining land, labor, and capital in a business enterprise, or combining various kinds of skill and talent in building a nation.

The building of a nation should be one of the aims, if not the sole aim of every educational system. The science of nation building requires as careful a study of the factors involved, and of the proportions in which they should be combined, as does the science of chemistry. Of all the factors required in the building of a nation, the human factor is by far the most important. Nations have grown rich in the midst of rather poor geographical surroundings by virtue of the fact that they have made good use of the human materials. They have grown poor in the midst of rich geographical surroundings by virtue of the fact that they have allowed much human talent to go to waste.

The leading forms of wasted human talent are: 1, the imperfectly employed; 2, the involuntarily idle; 3, the voluntarily idle; 4, the improperly employed. By the imperfectly employed talent is meant that which is capable of being trained for higher usefulness, but which, through lack of education, is never actually trained. Therefore, it is compelled to do less useful work when it might, had it been properly trained, have done more useful work. A potential genius being compelled to do unskilled work merely because he was never trained to do the highly skilled work of which he was capable, presents a picture of a wasted human resource. An Edison shoveling coal would be doing useful work, but less useful than he was capable of doing, and therefore he would not be perfectly employed. His talent would be partially wasted.

The involuntarily idle constitute the army of the unemployed. They do not seem to fit in anywhere, at least not in any place or position where men are needed. The demand for whatever useful talents they may have seems to be already over supplied. It needs no argument to show that such men are going to waste. If in order

to build brick houses, we need both bricklayers and hod carriers, and, if there should happen to be more hod carriers than were needed to wait upon the limited number of bricklayers, some of the hod carriers would necessarily be unemployed. If a few hod carriers could be trained to be bricklayers, it would help the situation in two ways. First, there would be a few more bricklayers to be waited upon and this would call for more hod carriers. Second, there would be fewer hod carriers. In these two ways the balance of occupations would be restored, and that is all that would be needed to relieve the situation.

The voluntarily idle, that is, the leisure class, and the improperly employed, that is, the criminal and predatory class, are obviously going to waste. They throw the whole population out of balance, but the restoration probably requires higher moral standards on the part of both classes.

The problem of restoring the balance in the other two cases, that is, when it is destroyed through the fact that some talent goes to waste through lack of training, and when it goes to waste because it is trained in too large numbers for certain occupations, is primarily an educational problem. Whenever one useful occupation is too highly paid and another too poorly paid, it is a symptom, though not the only symptom, of a bad balance. There are too few men available for the one occupation and too many for the other. The balance can be restored by training larger numbers of the rising generation for those occupations where men are scarce and smaller numbers for those occupations where men are too abundant. This requires of those who direct the educational policy of the nation a broad knowledge of the needs of the nation as well as of the capabilities of the individual pupil. They must be able to look over the field and to decide wisely where men are needed. This is quite as important as to know how such men are to be trained.

This problem, however, is too vast for any single mind, or for a combination of all the minds of the teaching profession. Not only must the attention of the whole teaching staff be constantly directed toward this problem, but that of the pupils and the parents must be familiar with it. The pupil himself knows something about his capabilities, and more about the kind of work which he enjoys. Also he has some idea, though perhaps an inadequate one, as to the openings afforded by different occupations and localities.

In order that school boards, superintendents, and teachers may decide more wisely regarding this vital question as to where men are wanted, and in what proportions, they need information. They

must read and familiarize themselves with the field and all its varied possibilities. In order that pupils and parents may decide wisely, they need the same information. The pupil and his parents may have only a local acquaintance with occupational opportunities. Even within their own neighborhood they may have only a superficial knowledge of these possibilities. The broader and more comprehensive their knowledge of occupational conditions and opportunities, the fewer mistakes they will make and the better they will distribute themselves. We can expect to have a balanced nation, wherein every occupation balances every other, wherein none is overpaid and none underpaid, only when this kind of information is widely diffused.

There are other symptoms than money incomes which indicate a badly balanced population and a need for men with special training to fill the gaps. A classical example was furnished by the founders of Harvard College who, looking out upon the colony and "dreading to leave an illiterate ministery to the churches when our present ministers shall lie in the dust," decided to found a school to supply the social need. Here was a group of men interested in nation building, or colony building as they then understood it. They said nothing about developing all-round men, or enabling certain young men to get the most out of life. Thinking they foresaw a serious social need, that is, a need for men with certain training, and a serious lack of such men, they set themselves the task of training such men. Whether they were correct in their diagnosis or not, whether they decided wisely or wrongly, depends upon how well they were acquainted with the social needs of the colony, not upon whether they had the right point of view or not. Their point of view was undoubtedly correct, and it is here commended to every board of education and other educational authority in the United States.

When a farmer finds that his soil is not producing what it should, if he is a wise farmer, he does not simply throw on more fertilizer. He first tries to find out what elements of soil fertility are needed and supplies those particular elements. When a dietitian finds that a horse or a man is improperly nourished, he does not merely prescribe more food. He first tries to find out what nutritive substances are deficient and then prescribes more of those particular ingredients. Educational experts have always tried to apply the same kind of wisdom, but they have sometimes lacked the national point of view. It is one thing to decide what kind of an education an individual pupil needs in order to "round him out," to make a "well educated man" out of him. We must realize that education is largely a process of "fitting in," of moulding the individual to fit somewhere

in the social framework. It is as necessary, therefore, to study that into which the individual is to be fitted as it is to study the individual himself.

Fitting the individual into the social framework consists mainly in training him to do something which the community needs to have done, and for which the community does not yet have enough men or women. However useful a certain kind of work may be in itself, if there are already more men ready to do that kind of work than the community can use, it would be a poor educational policy to train others. As between two occupations, both of which were useful and both of which were calling for more men, in one of which the scarcity and the need is greater than the other, it is better to train men, if they can be trained, for the former than for the latter.

It is sometimes said that there can never be an oversupply of labor. That may be true, but it does not touch the fact that there may be too much of a particular kind of labor, that is, more of it than can be used along with the other kinds that are present in a particular time or place. There may be a bad occupational balance, and this is just as bad for some of the occupations as though there were a general oversupply of labor. Generally speaking, they will prosper and be independent who fit themselves properly for occupations where men are very much needed because there are too few. They who enter occupations where men are not needed because there are too many will not prosper and not be independent. It is not only better for the individual generally to be well trained for an occupation where men are much needed than for one where there is no great need for more men; it is also better for the nation.

The best possible safeguard against a bad occupational balance, or the best way of securing and preserving a proper balance, is what is called pre-vocational education. This is a preliminary study of the whole vocational field before choosing a vocation or beginning one's training for it. This kind of study should bring information not only as to the kind of work required of one in each occupation, the kind and character of the materials which one is required to handle, the probable earnings, the effect on health, and all the other internal conditions of the occupation; it should also acquaint one with the market, the capacity of the occupation to absorb more workers, or the danger of a glut in the labor market, the chances of promotion, and a multitude of other external conditions.

From an economist's point of view, no branch of education can possibly be more important than this and no branch is in greater need of development and expansion. The present volume should

prove to be of incalculable value to the educational world, and through it, to the nation at large. It gives a bird's-eye view of the whole industrial field, with a somewhat minute description of the kind of work required in each of the leading specialized occupations.

The first question which every enterpriser should ask himself before starting a new business enterprise is, Does the nation need another establishment in this field? Will it help to balance up the nation's industrial system by supplying something which is now inadequately supplied? If this question can be answered in the affirmative, the first external condition of success is present. It only remains for the enterpriser to show reasonable business ability and managerial skill to make his success certain. Before deciding any occupation, the pupil should ask a similar question. Does the nation need more men in this occupation? Are more men needed here to restore or maintain the occupational balance? If this question can be answered in the affirmative, it only remains for the pupil to acquire the necessary skill and to show reasonable industry and alertness. Pre-vocational education should help him to answer this question.

The special aptitudes of the individual pupil must, of course, continue to receive large attention, but increased attention must be given to the places which he is to fill. The need for pre-vocational education was very clearly, if somewhat whimsically, presented by Sydney Smith in his "Sketches of Moral Philosophy:"

"If you choose to represent the various parts in life by holes upon a table, of different shapes,—some circular, some triangular, some square, some oblong,—and the persons acting these parts by bits of wood of similar shapes, we shall generally find that the triangular person has got into the square hole, the oblong into the triangular, and a square person has squeezed himself into the round hole. The officer and the office, the doer and the thing done, seldom fit so exactly that we can say they were almost made for each other."

Pre-vocational education should, of course, enable each peg to find the right hole. In the past there has been relatively too much study given to the pegs and relatively too little to the holes which they are to fill. The present emphasis upon pre-vocational education will go far toward restoring the balance here as elsewhere. It is primarily a study of the holes which the pegs are eventually to fill. From the economic point of view it is the most promising development in American education today. It promises to give us a well-balanced population which is as essential to national health as a well-balanced ration is to a steer, or as a well-balanced fertilizer is to an

imperfect soil. The old Greek motto "nothing in excess" applies to the national, as well as to the individual life, and to the occupational distribution, as well as to the geographical distribution of the population of a well-balanced nation.

T. N. CARVER,
Professor of Political Economy, Harvard University.

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STATEMENT

The fundamental aim of education is not simply culture, not polish nor poise, not dignity, not even knowledge for the sake of knowledge, but is the development of ability to render the greatest service to society in the most efficient manner,—the power **to think** and **to do.** This development includes training for specific lines of work, but such training pre-supposes a decision by the individual of the trade or vocation he is to undertake. Trained men, those who know how and can do things, should be the natural product of the schools, and the schools must provide the student with opportunity to choose his vocation. This can only be done through study, observation, and participation, all of which are necessary to form the foundation for any trade, occupation, or profession.

The student on leaving school will enter some line of activity. He should be expected to earn his living and he expects to earn more than a living, but it is self-evident that the average student could not be much of a success in just any vocation that he happened to undertake. To reach the highest success of which he is capable, he must select that vocation to which he is best adapted. Therefore, since he has several hundred lines of work from which to choose, and can only pursue one, and since it is true that, in general, there is one trade for which he is naturally best suited, assisting him to determine that trade—permitting him to find himself—presents the largest single problem in education. This is Pre-Vocational Education. As a basis for such training, this book was developed.

The work of every man is included under one of two great divisions of industry, **Producing** and **Service.** Some occupations might be classified under both, but each trade is placed under that division in which the most of its efforts are directed.

Producing industries are fundamental and universal. Throughout the civilized world their modifications are varied and numerous, but all of them may be placed under the five basic groups, Agriculture, Lumbering, Fishing, Mining, and Manufacturing. On basis of the above classification, the arrangement of text material covering these producing industries is divided into six sections, namely:

Section 1. Occupations.—The description of trades or groups of trades, possibilities and remuneration in them, requirements for entrance, advancement, etc.

Section 2. Materials.—The materials used in the trades, their natural forms, commercial forms, properties and adaptability for trade use.

Section 3. Tools.—Trade sets of tools necessary for different workers, including hand tools, machines and apparatus.

Section 4. Operations.—Description and illustrations of how tradesmen work, how they use equipment on materials to turn out products of value.

Section 5. Drawing.—Explanation of different kinds and trade significance of drawing, the language of the tradesmen.

Section 6. Pre-Vocational Shopwork.—Including both those projects which indicate trades or industries, and those which embody trade units of work, thus permitting students to do some of the work of tradesmen.

It is evident that a book, so broad in scope and so important in purpose, would require in its preparation the ability of more than one man. Accordingly, men especially suited to work out each division were selected. The title page presents these men.

On account of the variety of material covered by the book, the different phases touched, and the necessity for extreme care to be exercised in bringing about continuity of thought and purpose from material supplied by so many people, the editorial work on the text was no small undertaking. This has been most ably handled, however, by Charles Kettleborough, Director of the Indiana Bureau of Legislative Information and C. L. Quear, Scientific Assistant to President of Kansas State Agricultural College.

The illustrations were given more than usual attention on account of their especial effectiveness in visualizing industry, in portraying trade conditions, and in presenting details of operations. Valuable help was provided by various manufacturers and tradesmen, not only in connection with the illustrations, but in verifying the trade information.

The book is intended as a text for students in grades 7, 8, 9 and its arrangement permits of several methods of application. The sections may be considered, and completed, in the sequence presented or taken up in any order desired; or any trade or industry may be followed through the different sections; or the informational matter may be approached through the shopwork by considering those portions of different sections that apply to the piece of work undertaken. The flexibility of the subject matter enables any school to feature the lines of work predominating in the locality, but it is

probable that best results will be obtained through properly proportioning the time between informational and shop phases.

It is not to be expected that the completion of this material will insure a decision on the part of each student as to the trade he should undertake; but it will broaden his range of vision, and impress upon him the importance of proper choice of a vocation.

GUY M. JONES

SECTION ONE

OCCUPATIONS

by

R. H. RODGERS,

Director of Industrial Arts,

Stout Institute, Menomonie, Wis.

OCCUPATIONS

1. An occupation is that which engages the time and attention of an individual. It is the scheme of living. Every man, no matter what he does, lives through the operation of this scheme. An occupation may produce goods or render service and in either case it has a definite place in the development of the world. Most occupations have become so vital to progress, so great in scope and possibilities, that a group of men engaged in closely related work form an industry. Such industries as farming, mining, fishing, and manufacturing are the units upon which civilization is builded.

The success of each individual in life depends upon the part his occupation plays in the world's work. If that which engages his time is of no value to the world and of no service to his fellow men, then he cannot hope for reward from them. Again, if his time is so poorly spent, his results so crude and incomplete as to be of little value, even though directed along the most serviceable lines, his success will not be great.

Every individual, then, who hopes to succeed must give his time to some occupation that is of value. He must either produce or serve. If these were all the requirements to observe in choosing an occupation, the task would be simple, but the most difficult task is selecting that occupation for which one is best suited. "What can I do best and what would I enjoy best to do?" This is the determining question. What boy can answer himself that question? Yet every boy must either choose his occupation or have one thrust upon him, and he cannot choose unless he knows something of the requirements, duties, rewards, conditions, and possibilities of the desirable occupations. If he is unable to choose, he drifts into any available job and often follows a life's work for which he is unsuited, in which he has no interest and no future.

It is the intention of this section to give definite information on the requirements, possibilities, and returns of the work in the chief producing occupations. Work in the shop will help to determine ability. With a knowledge of occupations and an understanding of one's ability, the selection of the line of work to be followed may be made intelligently and a higher level in life reached than could otherwise be attained.

CHAPTER I

The Growth of Industry

2. **Industries Among the Early Peoples.**—The early peoples of the prehistoric period were concerned with very few wants. These wants may be grouped under three headings: food to eat; shelter from the weather; and protection from wild animals or other peoples. They lived close to nature which supplied them with raw materials in many forms. In the earliest stages of man's progress, these materials were used just as nature provided them. The flesh of animals, roots and herbs were eaten as they were found; natural caves and hollow trees afforded shelter; the skins of animals gave protection from the cold; and crude clubs and stones provided weapons of defense.

They had no permanent homes because the search for a livelihood carried them over a considerable area. The supply of food, either game or vegetable, at a particular place was soon eaten and then the group moved on to another source. It is quite probable that in the earliest stages both men and women hunted and that most of their activities were very similar. With the advent of the use of fire, more particularly in connection with the preparation of food, we note the first steps toward a division of labor. It became women's lot to care for the children, build the fires and prepare the food, while the men were engaged in hunting.

Students of early human life inform us that woman in thus assuming the task of preparing the food, laid some of the first steps in human progress. The woman, left to tend the fires and to piece out the scanty fare with the roots, stems, barks and leaves which she could find, began the various peaceful industries of life. She was the one who began basket-making; it was she who devised pottery; she first spun the fiber into thread and wove threads into fabric; it was she who worked out many of the mechanical processes and put them to practical applications; it was she who began the cultivation of plants and the taming of animals.

The cultivation of plants was another stage of progress. It marked the beginning of the era of semi-permanency in family or tribal life. To secure the advantage of planting, it was necessary to harvest, and, as a result, little villages or settlements sprang up and endured for at least the period of the planting and the harvesting.

The stages of development thus far indicated have shown the beginnings of the division of labor between the man and the woman.

The next division was between individuals of the same sex. Among the men, some were better hunters than others; some made better weapons; and this diversity of ability resulted in the beginning of barter, trade or exchange. Exchange probably did not stop with individuals within the same tribe or village but extended in some form to neighboring peoples.

3. **Industries Among the Ancient Peoples.**—Some of the most wonderful exhibits of industry today are the products of ancient peoples. The Pyramids of Egypt, the ruins of temples and public buildings in Greece and Italy are testimonials of industrial progress of a most striking character.

The first great laboring class of which there is any record was composed of slaves. One of the spoils of war in those days were the captives who were taken away and held in slavery. Biblical literature tells us of the trials and tribulations of the Hebrews while held in bondage by the Egyptians. The Great Pyramids were piled up as the result of years of toil by slaves and it was in this way in Greece and Rome that the great temples, public buildings and highways were constructed.

The Hebrews, following their delivery from Egypt when they started on their search for the promised land, made some beginnings in the field now called agriculture. They lived upon flocks and herds, which they drove with them, and upon the fruits of the soil which they tilled in many places while stopping on the journey. The skins of the animals slaughtered provided them with shelter in the form of tents, and the wool from the flocks gave them raw material for their garments. People living this type of life are said to be a pastoral people.

The working classes were made up chiefly of slaves for many generations, but slavery gradually gave way to serfdom, which is a modification of slavery; and this in turn to feudalism, a system in which over-lord and tenant were bound together for common protection and advantage. As the feudal system began to break down, serfdom also commenced to give way to a system by which labor was paid for, or as it is now known, the wage system. Serfs who were able to escape from the manors or estates of their over-lords to the so-called free towns or cities and maintain their liberty for a year and a day became free. In many of these free towns were found grouped together various industries and into these the serfs very frequently found their way. With the growth of the cities and towns, a new institution, called a guild, grew up which controlled and regulated the trade. Under the earliest guild system, manufacturing

was carried on in the homes, the householder being the master and usually having the assistance of a few learners or apprentices. These beginners lived as members of the family, the master being responsible for their training, their food and clothing. Eventually, after a period of training, usually seven years, they became journeymen and then in turn master workmen and probably the proprietors of little home shops. This system, called domestic production, gradually changed as the guilds became stronger and industry began to gather in and about the towns where little shops sprang up. The great monasteries were the seat of much of the finest handicraft work of this period. The wonderful cathedrals, tapestries, stained glass, pottery, carvings and sculptures were products in part of this system of industry.

During the sixteenth century the influence and power of the guilds decreased. Trade and commerce were making tremendous strides; communication was being improved; and the demands made upon industry were increasing many fold. At this stage the forerunner of the factory system made its appearance. Men with a little available capital bought raw materials in quantities, distributed them to a number of workers and later collected and disposed of them in the form of finished products. Under these changing conditions, the guild, with its many rules for the control of apprentices, quality and quantity of production had to give way to the factory system.

It is sometimes said that the factory system started with the invention of machines, but, as a matter of fact, its inception may be said to date back to the time when certain individuals with a little capital purchased the raw materials. Capitalism, as it is called, was the first step toward factory production, and the invention of machinery made its development possible to the fullest extent. Man's constant search for greater results with less effort has resulted in the production of many remarkable labor-saving devices and productive machines.

One interesting line of invention centered around the making of cloth from the raw material. We are all more or less familiar with the early methods employed, in which the cotton, hemp, silk or wool was spun into yarn by means of a distaff and spindle and later the spinning wheel. The pressing need for large quantities of yarn to weave into cloth led to the invention of a machine called the spinning jenny. This was improved and designed to operate by water power. In 1779 the principles of the two previous machines were combined and the mule-jenny produced. This made possible the pro-

duction of more yarn than could be used by the spinner under the old method of spinning. This situation was equalized by the invention of the power loom in 1785. It remained for the steam engine, perfected by Watt, and applied as a source of power in factories in 1785, to make certain the future development of industry.

With the development of machines and different methods of production came the final centralization of industry under one roof called a factory. The building and equipment involved large outlays of money. So, on one hand, are the people who invest the money and employ labor, and on the other, the people who are engaged to produce material products.

In the industrial age of today, there are found industries of all kinds established the length and breadth of the land. Usually, they are located near the source of raw materials or on lines of communication and also accessible to cheap power for operation. These plants are filled with machines and workers, each performing, in most cases, a single operation. This specialization is the logical outgrowth of the demand for increased production. One person becomes an expert in doing one particular line of work and consequently produces in each working day much more than the man who knows something about a great many machines but yet has not that special skill on any one. As a result of this practice, the long years of apprenticeship were not necessary and the apprenticeship system declined. This entire tendency is to secure a large output of manufactured goods, but in one vital aspect it is detrimental to the worker. As long as work is plentiful in the workman's particular field, he has employment and usually receives a fair wage, but immediately upon a shortage of work in his line, he is without employment and without the training necessary to enable him to change over to another line in the same general field. This situation has been recognized as undesirable and has resulted in legislation in some states providing for organized training of apprentices in the entire trade.

This so-called break-down of the apprentice system has been an important factor in the development of industrial education. The larger factor in this educational movement has been, of course, the trend of civilization toward doing things with mechanical devices. It is man's continuous striving after means that will lessen effort and increase output. No longer is there found the slow, laborious, hand methods, but on every hand are to be found the application of mechanical devices. The manufacturing plants turning out materials of every description are not organized for teaching young people in mechanical lines; and as a result skilled help did not keep pace with the development of industry.

The schools were very naturally turned to as the proper place to train the future workers in the fundamentals of the occupations. Thus, we have in the public schools the industrial arts work of the lower grades centering very largely around the general informational side of the subject. In the so-called Junior High School period, the students are brought in contact, for short periods, either through study or some experience, with a number of the leading occupations, for the purpose, in part, of enabling them to more wisely select their life work. In the last years of the high school, the opportunity is given to follow rather intensively a selected trade or occupation, thus preparing definitely for entrance into the world's work. This organization is not universal by any means in the public schools of the country, but is in operation in many places and points the way for general adoption. For the students who have left school at an early age, there are in most communities night and part-time schools where they may take up vocational work in some form or some of the more general subjects. National legislation and legislation in some of the more progressive states controls child labor and compels attendance at school, even while working, for a specified number of hours per week up to a certain age.

Thus, as we look back over the route which labor has traveled, we see the progression from slavery to serfdom, through the guild system with its apprentice idea, its evolution following the so-called industrial revolution down to the present day with its intense specialization and the taking over of its control, regulation, and even operation, in a large measure by the Federal and State Governments.

CHAPTER II

Present Day Occupational Groups

4. The entire trend of our industrial and commercial organization is toward large capitalization. While there are many thousands of small industrial plants, each producing something in a limited way, their output or amount of business is meager in comparison to that produced by the big iron and steel mills, the steel ship building plants, the huge saw mills and furniture factories, the great transportation systems and the large commercial houses engaged in trade and banking. The tendency of the period is to work on a scale involving millions of dollars and employing hundreds of thousands of workers.

As indicated in the previous chapter, this is also a period of specialization. So we find these large plants subdivided into departments, each one of which is engaged in turning out a particular type of product or doing a particular thing. This is quite as true in commercial establishments as in industrial plants. Each department is a unit and as such is closely related to the whole plant. If one department fails in keeping up to certain standards of quality and quantity, many other departments are affected, and in some cases the entire plant may be tied up.

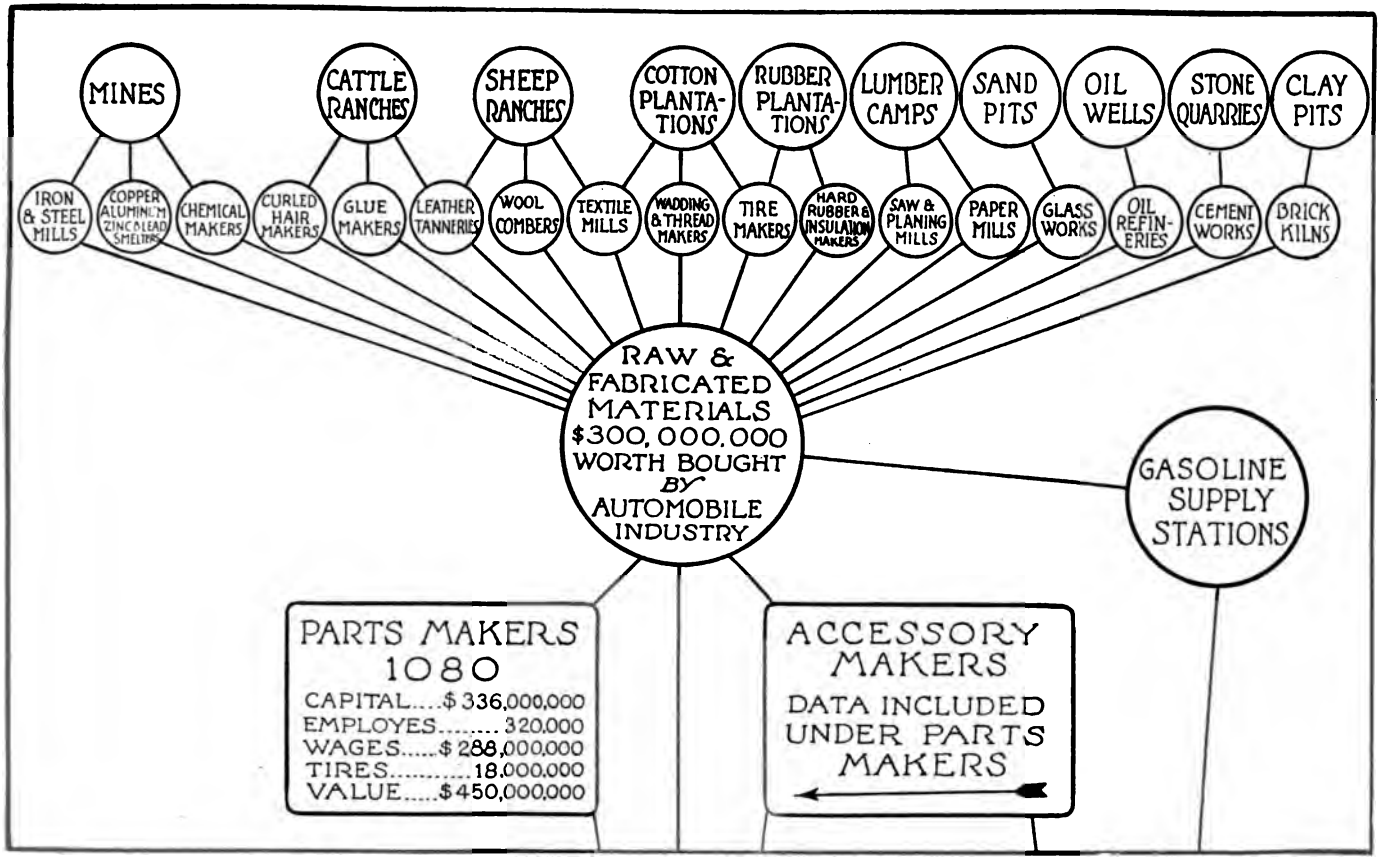
This interdependence between departments of a single plant or establishment is indicative of the relation between the various industries. The accompanying chart shows very clearly the scores of industries, millions of capital and the thousands of workers linked to the automobile industry.

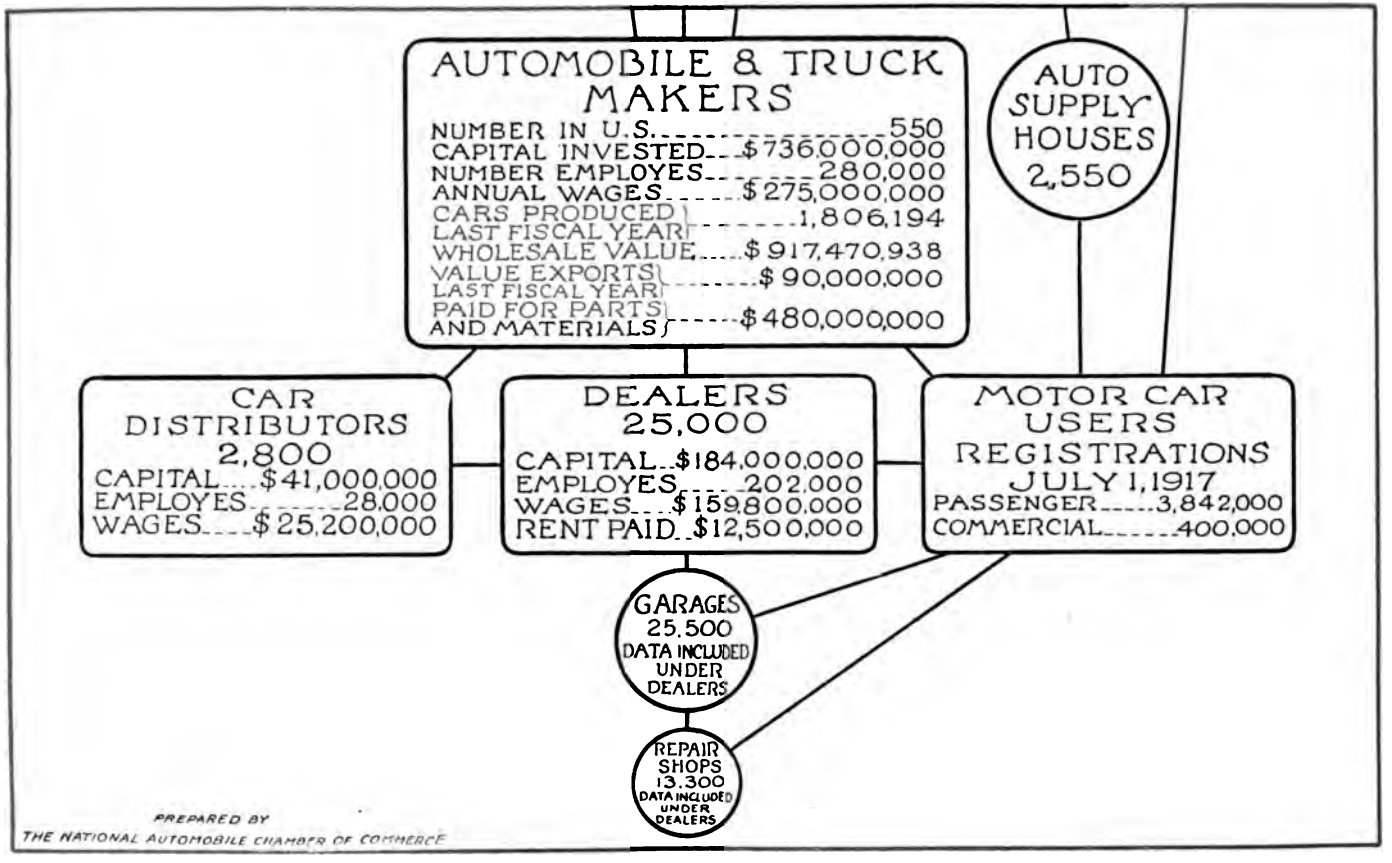
Any other industry might be charted in a similar manner and bear out this point of interdependence. This entire scheme, which we may term economic organization, must be so carefully adjusted and maintained that the needed articles are at the right place in the right quantities and at the right time. If the coal mines are closed for a short period and the production of coal falls short, it means the closing of many industrial plants and the shutting off of their output, which in turn may be needed in some other industry, and so it may go on in an endless chain until it affects the consumer who is the final sufferer.

General Divisions of Occupations

5. If it were possible for us to ascend to some very high point and then look out over the whole expanse of our country, we should see

CHART I.—THE AUTOMOBILE INDUSTRY.




AUTOMOBILE & TRUCK MAKERS
NUMBER IN U.S. 550
CAPITAL INVESTED $736,000,000
NUMBER EMPLOYES 280,000
ANNUAL WAGES $275,000,000
CARS PRODUCED LAST FISCAL YEAR 1,806,194
WHOLESALE VALUE $917,470,938
VALUE EXPORTS LAST FISCAL YEAR $90,000,000
PAID FOR PARTS AND MATERIALS $480,000,000
AUTO SUPPLY HOUSES 2,550
CAR DISTRIBUTORS 2,800
CAPITAL $41,000,000
EMPLOYES 28,000
WAGES $25,200,000
DEALERS 25,000
CAPITAL $184,000,000
EMPLOYES 202,000
WAGES $159,800,000
RENT PAID $12,500,000
MOTOR CAR USERS REGISTRATIONS JULY 1, 1917
PASSENGER 3,842,000
COMMERCIAL 400,000
GARAGES 25,500 DATA INCLUDED UNDER DEALERS
REPAIR SHOPS 13,300 DATA INCLUDED UNDER DEALERS
PREPARED BY
THE NATIONAL AUTOMOBILE CHAMBER OF COMMERCE

chains of mountains, rivers, valleys, forests, railroads, broad expanses of cultivated and uncultivated land, large cities, and small towns. In the open sections, we would find men plowing the soil, planting and harvesting crops, raising fruit and cattle; in the mountains, digging and blasting for ore and coal; in the forests, at work cutting the timber and getting it out of the woods; on the rivers, lakes and oceans, men engaged in fishing. In each illustration, it is a case of dealing with raw materials. To secure them is largely an extractive process.

In the cities and towns are not found the same kind of occupations. Here are the centers of manufacture employing large numbers of people. These plants take the raw materials as they come from the mines, the forests, the farms and the streams and pass them through processes that give them greater value. Many of these products are not transformed immediately to the final article. For example, iron ore from the mine goes first to the smelter and is made into pig iron and as such goes to iron foundries or steel mills where it is further transformed. In the timber cut in the forests, we have another example; first, it goes to the saw mills, and from there is distributed to be used for houses, furniture, pianos, toys and many other things. These latter processes are frequently called remanufacturing processes.

In these same big cities are found other large occupational groups. One of the most important is concerned with the circulation of money and the distribution of manufactured articles, such as clothing, food, automobiles, furniture and hundreds of similar articles to the user or consumer. These people are engaged in trade and they conduct stores, wholesale and retail, large and small, for the purpose of bringing the manufactured article to the user. In order that these finished articles may be distributed over wide areas of the country, and that people may move rapidly from one point to another, we have systems of transportation, both water and rail, which is another large occupational group. A further group is concerned with the health, morals, and education of the people, their spiritual welfare, the perfection and interpretation of laws, improvement of living conditions and the designing and improving of mechanical and producing appliances. The doctor of medicine, the teacher, the minister, the lawyer, architect, and engineer are grouped into what is known as the professions. Again, there is the public service group made up of policemen, letter carriers, firemen, soldiers, and officials engaged in carrying out the wishes of the people and the enforcement of laws. Others are engaged in domestic and personal service such as barbers, hotel workers, housekeepers, servants, laundry workers, waiters and others. The final group consists of the clerical

workers engaged in bookkeeping, accounting, office clerking, stenography, and typewriting.

The above analysis shows two large general occupational groups; one that may be called **producing**, which means extracting and transforming materials from the raw or semi-raw state to materials of greater value; the other, the service group, including practically everything outside the first field. The accompanying tables, from the U. S. Census for 1910, give the number of persons over ten years of age engaged in the principal occupations. The World War has materially affected the number of workers in many fields, and, in manufacturing, this has resolved in two general divisions, the essential and the non-essential industries, the grouping being made according to what they contribute toward the successful termination of the war. This has resulted in shifting many more people than the tables show into the metal working and allied industries.

Table 1

Producing Occupations

Occupation	Total
Agriculture, forestry, fishing and animal husbandry	12,659,203
Mining	964,824
Manufacturing and mechanical pursuits	10,658,881
Total	24,282,908

Service Occupations

Occupation	Total
Transportation	2,637,671
Trade	3,614,670
Professional service	1,663,569
Public service	459,291
Domestic and personal service	3,772,174
Clerical occupations	1,737,053
Total	13,884,428

Summary

Group	Total
Producing occupations	24,282,908
Service occupations	13,884,428
Total	38,167,336

A large portion of the population cannot be properly classed as workers in the producing industries. Among the population there

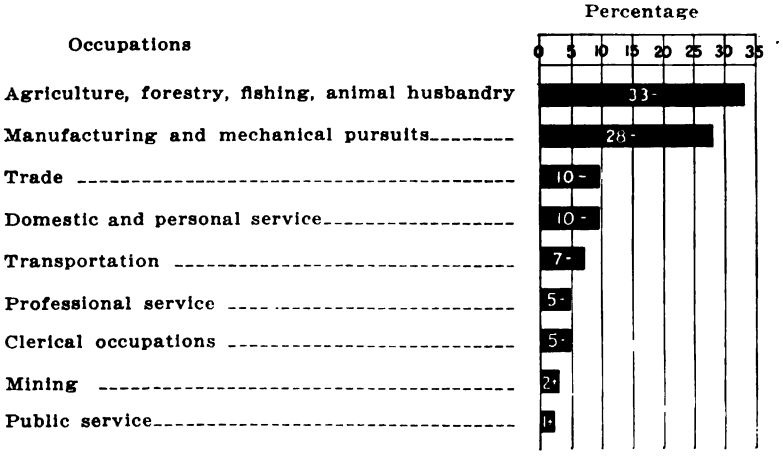
are large numbers who are too old, too young or in some way so incapacitated that they cannot properly be classed as gainful workers.

A glance at Chart II shows that only 41½% of the population are gainfully employed. These figures eliminate the home-makers and those incapacitated by age or infirmity; in other words, 58½% of our people belong to these groups.

The burden of the production of the things necessary to life and comfort is carried on by less than one-half of our population. The actual producers in industry are only about one-fifth of the population.

More than six out of every ten persons at work are engaged in the so-called producing occupations, and the remainder, something more than three out of ten, are in the service occupations. About one in every ten workers is engaged in trade or domestic and personal service. In transportation are found about seven out of a hundred; in public service, about one and a half per hundred; in professional work, something more than four per hundred, and a like number in the clerical occupations. The following chart shows the distribution quite clearly.

CHART II.
DISTRIBUTION OF WORKERS IN INDUSTRY



CHAPTER III

Producing Occupations

AGRICULTURE

6. The previous chart (No. II) indicated a group of producing occupations, and in the following pages each group is discussed separately for the purpose of directing the future worker in choosing his life's work.

Fig. 1.—A modern farm.

Agriculture ranks first in importance among the industries, both in the number of workers employed and the value of the product. The food we eat and the clothes we wear have their beginning in the hands of the workers of this group.

Table 2

	1910	Per cent
Total population	91,972,266	100
Number engaged in gainful occupations	38,161,366	41.5
Number engaged in agriculture	12,659,203	13.7

The number of people engaged in agriculture in 1910 was 13.7 per cent of the total population. Of all people engaged in gainful occupations, 33.2 per cent are engaged in agriculture. See Table 2. In other words, of all people in all lines of gainful work, one out of every three is engaged in agriculture. Agriculture employs more men than any other occupation. Since there are so many people engaged in this basic industry, it is apparent that agriculture should at least receive consideration by a person before deciding upon his life's work.

Who Should Study Agriculture

7. Every person should know something of the fundamentals of agriculture. The city boy or girl who does not expect to become a

Fig. 2.—Pig club boys studying hogs on a farm.

farmer will consume farm products. Knowledge of how the farm crops are produced, and their value, will aid the consumer in co-operating with the farmer in buying well and wisely and in looking upon the business of farming in the right light. The man in town is more dependent upon the efficiency of agricultural production than upon any other thing. In fact, it is only the high development of agriculture that permits large cities. This inter-relationship of agriculture and all other development should be a part of the education of every individual.

8. **Divisions of Agriculture.**—Broadly speaking, agriculture may be divided into two general divisions: general farming and specialized farming. General farming is the largest division in point of numbers, more persons being engaged in general farming than in all branches of specialized farming.

The general farmer needs to be well informed. He is dealing in both crops and animals. He has to know methods of profitable production, marketing and buying. He must be a mechanic, as well as a business man and a producer, and must be able to compete on all sides with specialists in each line of farming.

9. **Tendencies of Farming.**—The general farmer is essentially a small farmer. Large farms tend toward specialization. It is said that this is the age of specialization and that the small farmer with forty or sixty acres must give way to the larger farmer. That this is the age of specialization seems to be true, but that the small farmer must go is not so evident. Table 3 shows that during the decade from 1900 to 1910 the average size of farms has decreased from 146.2 acres to 138.1 acres. This tendency indicates that farming in the future will be on smaller farms, and that general farming is in the ascendency. That this

Fig. 3.—Some fine hogs enjoying the water.

is true is due largely to two vital facts. On the small farm the family can do most of the work, and, with diversified farming, work is to be had all the year. On the specialized farm, it is the alternate busy and idle periods that cut down profits. Therefore, it is wise for the person contemplating agriculture for a livelihood to become familiar with general farming both because the trend of agriculture is in that direction and because it is an excellent foundation for any breach of the industry.

Table 3

Average acreage per farm in the United States

	1900	1910
Improved land	72.3	75.2
Unimproved land	73.9	62.9
Total area per farm	146.2	138.1

Per cent of decrease for the 10 year period 1890 to 1900, 8%; from 1900 to 1910, 5.5%.

Daily Work of the General Farmer

10. The general farmer has a diversity of operations to perform and a great deal of work to do. To produce cereal crops, forage and pasture crops, vegetables and fruit and, at the same time, care for horses, cattle, swine, sheep and poultry, requires not only a great deal of energy, but careful planning to do so many things. No amount of skill, science and machinery will relieve the general farmer from long hours of work. The general farmer must do more work than the specialized farmer, which means that he must either employ more help, which is unprofitable, or work longer hours. However, the amount of muscular labor required in farming has been steadily cut down for the last seventy years through the use of machinery until the farmer does not have to work nearly so hard as formerly.

Fig. 4.—Breaking ground with gang plow.

Agriculture is too complex for all its details to be mastered by one person and the general farmer is obliged to carry on some

activities with which he is not thoroughly familiar. For this reason, he cannot hope to secure the best results. He is, as it were, a "jack of all trades." As far as daily work on the farm is concerned, these two facts, the long hours, and the lack of scientific knowledge, are the worst conditions. On the other hand, the man on the farm is not governed by a whistle. While he works long hours, the knowledge that he can take a day off without interfering materially with the progress of his work is worth while. Besides, the diversity of operations helps to relieve monotony. If a farmer had to plow all day, every day in the year, as a machinist has to punch holes, the work would be much less desirable than it is. A change of work is a rest and a mental stimulant. While the lack of complete information on all phases of agriculture is a handicap to the general farmer, the fact that he is practicing the many phases keeps him mentally alert and is a great factor in relieving the tedium of long hours.

Fig. 5.—Cutting hay.

11. Out Door Life.—The beauty of nature makes out door life one of the greatest assets of farming. The brooks, the woods, the meadows, the hills, the birds, the beautiful colors are present in endless succession and serve to give an attraction to farming which the factory or store can never have. Moreover, the healthfulness of the open air life is of direct importance. The fresh food and air, the freedom from the noise and turmoil of cities, from close contact with masses of people and its attendant danger of contagious diseases, make farms the homes from which leaders of our nation will come in the future as they have in the past. If farmers as a class would advertise advantages of farming as city organizations ad- their respective cities, the demand for farm land would exceed any real estate prosperity that city attractions have ever produced.

Fig. 6.—Planting corn.

12. Use of Farm Machinery.—Farm machinery has done much to relieve farm life of drudgery. The advent of farm machinery has

Fig. 7.—A hay loader in use.

Fig. 8.—Plowing.

been recent. As late as 1845, the people of the United States did not raise enough wheat for their bread, and only 4.3 bushels of corn per capita. Even if they could have raised more wheat, they could not have harvested it. Today, for each person in the United States, ten bushels of wheat and 30.4 bushels of corn are produced. Instead of requiring 4½ hours to produce a bushel of corn, as was required in the middle of the thirteenth century, it now requires less than forty minutes. Thus, farm machinery has increased the per capita production. In other words, a man can now produce much more than he could a century ago and he can do it with less muscular work. He has come to use his brains in farming, and instead of cutting wheat with a cradle as was done before the time of Christ and until as late as 1850, he uses a great header which cuts a swath twelve feet wide and delivers the grain in a golden stream as rapidly as a tractor can pull the header through the field. By hand methods as of old, there could not be produced enough wheat to feed the people of today. In 1830, it required three hours of a man's labor to produce a bushel of wheat; now, it requires eleven minutes. With better machines came better food, more leisure for the farmers and the need of more intelligence. It requires less human

Fig. 9.—Gang breaking plow drawn by tractor.

muscle to cut wheat with the header than with the cradle but infinitely more intelligence.

Other inventions lightening the labor of the farmer are so numerous and well known as to need no mention. Among the most important are the steel plow, self-binder, cotton gin, and gas engine.

13. **Returns of Farming.**—Whether an acre of ground produces more or less than it did centuries ago is not known, but it is certain that we produce more per man than was ever produced before. That is, it requires less manual labor to secure food than ever has been the case in history. It might be inferred that as food is more cheaply produced farming is correspondingly unprofitable. This is not the case. The percentage of farmers decreased because our needs for railroads, automobiles, factory-made clothes, machines, etc., took the men who might otherwise have been farmers. There are now about 12 men engaged in agriculture to each 100 of our total population. A smaller percentage of farmers produce food for all than ever before, and there is more food for each. Therefore, while food is produced more cheaply, each farmer produces more of it and his profits are as great or greater than formerly, due to the increased production.

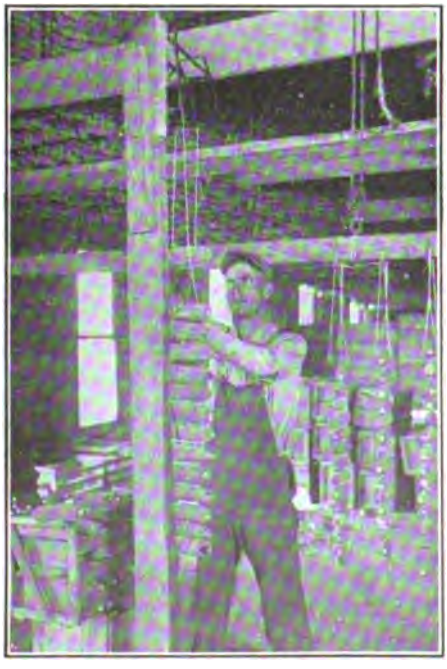


Fig. 10.—Stringing seed corn.

A very important thing to consider in the business of farming is the coming scarcity of land. Heretofore, land has been plentiful in the United States, but that is ended. The increase in acreage of improved land can not now keep pace with the increase in population. From 1900 to 1910 the population increased 21 per cent, while the total farm acreage increased only 4.8 per cent. This condition helped to cause farm land to increase in value 118 per cent from 1900 to 1910. Land will probably continue to increase in value, for there are no more large tracts to be had cheaply. This condition indicates that farming will be profitable in the future because the land

itself will be a profitable investment, due to its increase in value, and foods will increase in price at the same time being easily produced.

The farmer is entering upon a new era, the most profitable and enjoyable he has ever experienced. While the future for the farmer is bright, not every one can hope to become a farmer. Because farming is a desirable occupation is not a sufficient reason for a boy to be a farmer. He may not be suited temperamentally, educationally or physically. He must be reasonably sure that he would not be a misfit at farming before deciding upon it as a vocation.

14. **Social Life.**—The social life to be enjoyed is probably the most vital thing in choosing an occupation, although remuneration receives much attention,—probably too much. The social life of the farmer has undergone a wonderful change during the last generation. Just a few years ago the farmer went to town only when some need made the trip necessary. On such occasions, the trip necessitated a day's time, usually in a wagon loaded with farm products. Over the bad roads, the trip was not pleasant and the farmer was glad when it was over. While in town, he carried on no other activities than mere buying and selling. He did not belong in the city, he was out of his element, and the city did not make him feel welcome. In short, he was cut off from all outside social activities. The city church had almost closed its doors to the farmer a few years ago, not that he was not welcome to enter, but once inside, the social life of the church did not include him.

Fig. 11.—A meeting in consolidated school auditorium.

Fig. 12.—A farmers' picnic. Expert from the state agricultural college delivering a lecture.

Having little outside relations was bad, but the lack of community social activities, was worse. Bad roads, scattered living, scant means of communication, few gathering places, all tended to discourage social life. Probably the wife, or mother, from necessity, made the trip to

town once in six months; she went to church over the bad roads, but little oftener; and this practically ended her social activities. At school age the children attended school only a few months, and the attendance was almost too small to supply the need of social intercourse.

Contrast these conditions with those of the present day in most localities. Today, the communities not touched by rail and interurban are few. Good roads make traveling overland delightful and, greatest of all, have made possible the rural mail and parcel post delivery. News and parcels reach the farmer almost as quickly as they are delivered in the city. He knows what is going on in the national life and is a part of it. No longer is he isolated. More wonderful still is the telephone and automobile. He can converse with his friends at leisure and can call upon them personally in a few minutes. He can come to town in the evening or at noon and it is no longer a dreaded trip. The children are not isolated. They can grow up with the physical advantages of fresh air and wholesome food, and the mental stimuli of social relations with the community and with the adjoining city. The interurban, automobile, telephone and daily papers have brought the city to the farmer. He now enjoys the benefits of country life in addition to most of the conveniences of the city.

Fig. 13.—The big threshing dinner.

15. **Independence of the Farmer.**—The farmer has the benefits of that greatest heritage, Democracy. He need not fear that his job may suddenly be taken away from him because of the fancy of some employer, changes in business conditions, or because there is no further demand for his product. Investment in land is safe, speculation is reduced to a minimum, and the farmer can count his assets without numerous "ifs" to offset their probable value. He does not have competitors trying to get his business. When old, he is not discharged because a younger man can do his work better. His expenses are low, yet he lives almost luxuriously. Besides, he can go and come almost at will. The work must be done, but to some extent, it can be done according to the pleasure of the farmer and in his own way. In a large way, the farmer has less to worry him than almost any other producer.

16. The Modern Farm House.—Forty years ago the average farm home was neither a desirable nor convenient place in which to live. Even now, in some communities farm homes are not much improved. But modern conveniences have been adapted for use in farm homes and new ones invented until the progressive farmer can and should have most of the conveniences of the city home. In the average farm home of twenty years ago there were such conveniences as wood heating and cook stoves; a well, probably located several rods from the house, from which water had to be drawn with a rope and bucket; washboard, a dash-churn and dim burning kerosene lamps. For transportation, there was a wagon and almost impassible roads. For communication, there was the mail to be obtained weekly or semi-monthly from the postoffice in town. There were no artistic house decorations, either exterior or interior.

Fig. 14.—Enjoying the noon rest time with the morning's mail.

Today the good farm home has a lighting system, either acetylene gas, gasoline or electric. Heat is furnished by a furnace, and cooking is done on a kerosene, gasoline or gas stove. Water is pumped with a wind mill or gas engine and the same source of power runs the washing machine, the churn, and the cream separator. The running water supplies a bath room and kitchen, and waste water is disposed of through an efficient and sanitary system of soil pipes. The telephone connects the family with the neighborhood and mail is received daily. The automobile furnishes ready and almost instant transportation. The school automobile takes the children to large consolidated schools, where the community spirit is found.

17. Classes of Farmers.—Farmers may own their farms, they may rent them, or they may be working for definite hire. Table 4 shows the percentage of farms operated by owners, compared with the

percentage operated by tenants or renters. Note that the percentage of the farms operated by tenants has steadily increased while the percentage operated by owners has decreased. The fact that tenancy has increased during the past years is a very sad blow to the increase. Indications are that this will be true. Recent improvements have so improved farming conditions and farm life that men who own farms are more willing than formerly to remain upon them. Also, the high value of land and farm products has made it necessary that the work be closely supervised, if a profit is to be realized.

Table 4

Percentage of farms that were operated by—

	1880	1890	1900	1910
Owners	74.4	71.6	64.6	63.0
Tenants	25.6	28.4	35.3	37.0

For the hired man on the farm to ultimately become the owner of a farm was not difficult when labor was worth $15.00 a month, rent, garden, etc., free, and land selling for $30.00 an acre. But with the gradual increase in the value of good land to $200.00 an acre and wages $30.00 a month, it became virtually an impossibility. To aid the man on the farm to obtain his own farm, in the hope of decreasing tenancy, rural decadence, soil depletion and all evils attendant upon tenancy, the Federal Farm Loan Act was passed by Congress. Its purpose is to advance money to responsible farm laborers towards the purchasing of land. Copies of this act and its provisions should be carefully studied by every student of rural activities. It has been a great step toward rural betterment.

Fig. 15.—Shredding fodder.

The farmer who has saved a reasonable amount of money may become the owner of a farm, by first becoming a renter. As a renter,

Fig. 16.—An up-to-date farm milk house.

experience can be gained at the same time the money is obtained to buy a farm. Land is rented in different ways, as "cash rent," "renting on shares," and "stock-share lease." The terms of the various contracts vary, depending upon many conditions, as the amount of money the tenant has to invest, the size, and kind of farm. Practically the only hope for the man who works for wages on the farm to become an owner is to become a tenant or obtain help from the Federal Farm Loan Bank. While fifty years ago he could hope to save enough as a laborer to buy a farm, he could hardly do it now in a life-time of work.

18. **Homesteading.**—At the close of the Civil War, the most fertile portion of the United States, the Mississippi river valley, was opened to homesteaders. The most desirable land was soon taken, and the remainder has been gradually taken, until at the present time very little desirable land is left for government entry. In the United States most of the land that is available is either entirely unsuited to farming or else suitable only for special purposes. There is at present 279,544,499 acres of land unappropriated and unreserved in the United States. Rules governing homesteaders, in general, allow citizens without capital to obtain farms. While the hardships and privations are many, such a method will be followed in taking up the government land until it is practically exhausted. The homestead law works to the advantage of both the government and the individual. The government gets the land in service for the nation and the individual obtains a farm. Any person who is the head of a family, or who is twenty-one years old, and a citizen of the United States, may acquire a tract of land, in most places, not to exceed 160 acres in size, on condition of settlement, cultivation, and occupancy for five years. The money fee required is small. The five year period of residence may be shortened by the payment of a certain portion of the land value in cash. More than 85,000,000 acres of land have been homesteaded.

19. **Training and Education.**—In the past, the idea prevailed that

when a man could not do anything else he could farm. Even now many people think that a farmer needs no schooling, while many more consider a common school education sufficient. Agriculture in its successful practice follows certain well defined principles, which should be mastered by the young farmer early in his career, and it is true beyond question that education is one of the most valuable assets of the farmer. To produce large yields on the farm, better crops, finer animals, and to practice better economy requires skill and knowledge. To increase soil fertility, plan the drainage, fencing, farm buildings, and rotations, requires mechanical and business ability. Many of these things may be learned from experience, but experience is a slow and expensive teacher.

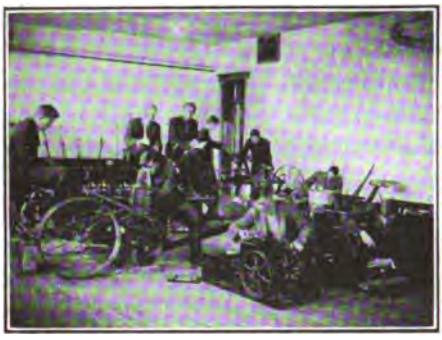


Fig. 17.—Farm mechanics class in an agricultural high school.

Without doubt, the farmer would be benefited by a four year college course. If he is successful without such a course, he probably would be more successful with it. No person should consider himself adequately prepared for farming without having had at least a high school course, agricultural in its nature. Competition is more and more weeding out the uneducated farmer. Until quite recently we did not have agricultural high schools preparing students for farm work. The need for such schools has become so apparent that agriculture is being taken up in most high schools and both State and Federal aid is offered to induce practical work along this line. The rapid strides towards introducing agriculture in the schools is shown by the great number of agricultural texts and bulletins that have been prepared in the last few years.

Graduation from an agricultural course in high school is an excellent start but should be supplemented, if possible, with a four year college course at the State Agricultural College. At least some of the "short courses," given during the slack season of winter, which present solutions to practical problems, should be attended. These courses are handled by specialists and they will give information which years of experience might fail to disclose.

Also, listed with teaching helps, there is the County Agricultural Agent working through the Extension Department of the Agricultural College, as well as special representatives from the State Experiment Station. These specialists are working for the interest of the farmer

and student, and at all times are glad to help on any or all problems. Where a man cannot go to school, the extension men of the college bring as much of the college to him as is possible. It is not only foolish, but a mark of ignorance, to refuse to make use of the knowledge of such specialists. Then there is the farmer's institute, the club work, the grange, and kindred organizations beneficial socially as well as agriculturally. No farmer can attend these meetings without finding much of value. Aside from school education and knowledge gained from personal contact with specialists, there remain text books, bulletins, circulars, and farm papers. Bulletins and circulars are furnished free of charge by both State and Federal Agricultural Departments. A letter asking to be placed on the mailing list will bring regularly a list of all bulletins and circulars published. Many excellent text books are contained in school and city libraries which can be had without charge. Too much cannot be said in regard to the good agricultural papers. Most of them are reliable, attractive and a constant source of information and inspiration.

With all these sources of information there is no reason for a farmer to proceed blindly along any path of farming. He has only to ask to obtain that information which often is the means of increasing a crop or preventing a loss from some practice which is not in accord with well established argicultural principles.

20. Specialized Farming.—Specialized farming is a relative term and includes not only the several lines of farming, but various degrees of specialization in each line. A man might do general farming and still place emphasis upon one line, as swine production. He might produce hogs as the main product, all else being secondary, or he might carry the specialization to the extent of producing only one certain breed of hogs. Specialized farming should not be confused with intensive farming. Specialized farming is the growing of one product, or class of products, for market, and it may follow either "extensive" or "intensive" methods.

(Copyrighted by Underwood & Underwood, N. Y.)

Fig. 18.—Baling alfalfa hay in Arizona.

Specified farming is developed to meet a definite need, and is usually a gradual outgrowth from general farming. Thus, a farmer may find it enjoyable and profitable to keep dairy cows, and as a result gradually enlarge the dairy fairm. In the same way almost any branch of the general farm may be developed because of the farmer's limitations. It takes a large amount of capital to become a wheat farmer in western Kansas, or a stockman in Texas. With small capital, truck gardening would more likely be undertaken. Growing cultivated crops, such as corn or cotton, requires much labor and, if it is desired to get away from heavy physical labor, such a farm should not be purchased. Capital, climate, location and the size of the farm, natural likes and dislikes are chief factors in determining the line of farming best for the individual to undertake.

The lines of farming which have been most profitable during the last few years offer no indication of the one best to follow. The returns to be expected from any line of farming must be based upon the future outlook of the business, rather than upon present market prices.

Stock raising, dairying, grain farming, cotton growing, fruit growing and market gardening will be briefly described here in the hope of comparing their opportunities, advantages and disadvantages in such a way as to aid the reader in choosing intelligently a special line of agricultural work.

21. Stock Raising.—Those men who obtain their living by selling goods learn the wants, and the knack of pleasing others. This is the secret of their "business ability" and such business ability is a vital factor in stock raising. Those who would become stock raisers must give careful attention to the needs and nature of the animals they produce. It requires a fund of knowledge concerning animals, markets and feeds to produce stock profitably, and a man who does not like to handle animals will be slow to master this knowledge.

Fig. 19.—Feeding a herd of cattle.

Formerly, stock raising was practiced chiefly on the range land of the West and Southwest. This land was cheap, could be

Fig. 20.—The sheep pasture.

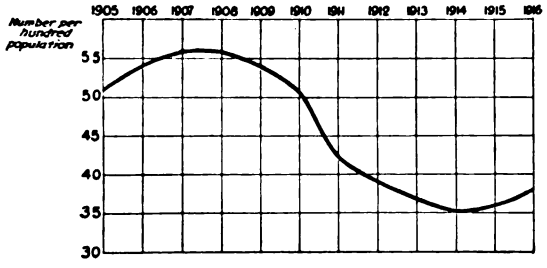
Fig 21.—Marketing stock by motor truck.

procured in wide tracts, and animals could be produced on a large scale at a low cost. But with the increase of population, and the breaking up of range land, methods of stock farming had to be largely re-adjusted. Today, stock raising is undergoing a revolution in the United States. The stock farmer who owns or controls cheap range land can, of course, produce live stock at a good profit, but the difficulty lies in securing such land.

Some productive land will never be able to compete with the level and fertile regions and will probably continue to be devoted to stock ranges. The Appalachian highland region extending from Maine to Georgia is an example. But there is very little range left as compared to the areas of former years.

Irrigation and better farming practices are bringing much of the western range land under the plow. The large stock ranches are being steadily broken up. Recently the price of land has so advanced that a high price must be obtained for animals to pay for producing them. Partly as a result of this, the number of beef cattle produced per capita in the United States is decreasing. This is shown in Chart III. If this decline continues, as it bids fair to do, the United States will have to depend more and more upon other countries for meat or consume less of it. As for horses, machines and other mechanical devices are rapidly replacing depleted horse power.

CHART III.—NUMBER OF BEEF CATTLE IN PROPORTION TO THE POPULATION.



22. The Stock Farmer on High Priced Land.—A stock farmer having high priced land can succeed, if he specializes in making the land produce more feed. He cannot give all his time to producing animals, but must devote some to cropping the land. If, on the range, five acres of natural pasture will support one steer, with the addition of a little grain at times, and the land is worth $10.00 an acre, the investment per steer for the range is $50.00. To carry steers at the same price on $100.00 land would require that one acre furnish the major portion of feed for two steers, or ten times the amount produced by one acre of natural pasture. Besides producing this amount of feed, it must yield enough more to pay for labor and seed used in cropping.

The increase in the value of live stock has helped to make their production profitable, but the growing competition from the general farmer has made the business of stock raising, as formerly practiced, precarious.

23. Growing Pure Bred Stock.—Stock raisers, having to use valuable land and compete against the general farmer, find in these requirements a partial solution of their problems. Since it costs more to produce animals, stock raisers produce a higher class of animals, and as the general farmer demands good breeding stock, the stock raisers sell pure bred stock at fancy prices. In other words, many successful stock raisers have become more highly specialized than formerly. Instead of producing for the general market, they produce breeding stock for those who supply the general market. From "extensive" stock raisers they have become "intensive" stock breeders. While this applies to many, there are still large stock ranches producing stock for the general market at a profit.

The man who loves animals, who enjoys the sight and handling of sleek, well rounded cattle, and snappy two-thousand pound drafters, instead of being satisfied with patchy scrub cattle and twelve-hundred pound poorly shaped work horses, and who has capital, and good judgment in buying and selling, can succeed in stock raising almost anywhere in the United States.

The Dairyman

24. Location of the Dairy.—While growth of cities and increased population are breaking up the stock ranges, they are aiding the dairy business. A city furnishes a ready market for fresh milk, and a dairy farm, located in easy reach of a city, has its market fairly well assured.

Fig. 22.—Milking room in modern dairy.

With the utilization of milk trains, interurbans, and motor trucks the distance that milk can be delivered fresh has been greatly increased until it is common for large cities to draw their milk supply from farms within a radius of fifty miles or more.

The desirable location for a dairy is within easy reach of its market. Where the milk is marketed fresh to the consumer, in general, the closer the dairy is to the consumer the better. Short hauls permit milk to be delivered cheaper, more quickly, and in better condition. Where the milk is not marketed but cream is sold, location is not so vital. Creameries handle cream obtained anywhere within a radius of 200 miles. The invention of the cream separator has greatly aided in this respect, permitting cream to be started on its way to market almost as soon as the milk is obtained from the cow. The advantage of locating the dairy where population is thickest is partly offset by the high price of land in such regions. However, the dairy cow is the most economical producer of human food and is adapted to high priced lands. For example, land in Holland, valued as high as $1,000 an acre, is used chiefly for raising dairy cattle and dairy products.

Fig. 23.—A dairy barn.

25. Products and Marketing.—Nearly one-tenth of the farm income of the United States is derived from dairy products. The market for dairy products exceeds the supply, and large quantities of butter and cheese are imported annually. Dairy products include milk, cream, butter, cheese, and ice cream. Whole milk may be marketed direct to the consumer; or it may be sold to a milk station, or to a condensed milk company. The producer selling to the consumer receives the highest price for his product, although it requires much work and added equipment to maintain a distributing system.

Formerly there was little financial encouragement towards producing pure milk under sanitary conditions, as people exercised but slight discrimination in its purchase. As the highly perishable nature of milk came to be realized, and as standards of purity became established, the man who produced milk under ideal conditions found a ready market at a higher price. To produce sanitary milk requires knowledge and care and the dairyman of today needs a dairy education to compete with rapidly advancing milk standards.

Selling milk to milk stations is practiced widely by small dairymen and general farmers who have only a few cows. Selling milk to milk stations at 12 cents a gallon is much less profitable than selling it to the consumer at 48 cents a gallon. But for the small dairyman, selling to the milk station is convenient and not unprofitable.

Fig. 24.—A creamery wagon collecting milk left on the stand by farmers.

Condensed milk companies take a great deal of milk that could find no other outlet. They have multiplied rapidly in the last few years due to the demands of our Army and Navy, and the Allies.

Creameries pay good prices for butter fat in the form of cream, and where the dairy is located at a distance from a desirable milk market the creamery provides an outlet for the product. Selling cream almost demands a cream separator, but a separator is a profitable investment for the person who sells either cream or butter. Besides, a cream separator saves a great deal of labor in the handling of milk. One distinct advantage in selling cream is that skim milk may be used to feed farm animals, as calves and pigs. It is a valuable food for young stock.

(By U. S. Department of Agriculture.)

Fig. 25.—Bottling room in modern dairy.

The milk may be converted into butter at home, but the large creameries with efficient machines produce a more uniform product than the small dairy and at as low a price. The labor involved in butter making, as a rule, makes it an undesirable business for the dairy of moderate size, located where milk or cream can be sold. However,

butter is the best form of marketing dairy products from the standpoint of conserving the farm fertility. A ton of butter removes less than 50 cents worth of fertility from the soil. The feed which cows consume in producing this butter fat, if sold, would remove several dollars worth of fertility, but when fed to the animals its fertilizing value is retained on the farm.

Cheese making is not extensively practiced in the United States. We do not consume so much cheese as other countries, but prefer more butter. The people of the European countries produce much cheese, and do it so cheaply and skillfully that we can not compete with them in their markets. However, in certain regions of the United States, as Wisconsin, cheese making is practiced on a profitable basis and a dairyman should know something of this product and its possibilities.

26. **Equipment of the Dairyman.**—Equipment varies with the manner in which the product is marketed, but, as far as caring for cows is concerned, the equipment is about the same. The most important equipment is a knowledge of dairy cattle; next, come good cows; and third, good surroundings and good help.

Knowledge of dairying can best be obtained in college, but much can be learned from successful dairies, from publications and close observation. The milk from each cow should be tested for butter fat percentage and the pounds of milk produced by each recorded daily. In this manner unprofitable cows can be weeded out of the dairy herd. Sanitary buildings and good feed will go far towards making good milk in large quantities. This requires land for growing feed, silos and bins for storage, and good barns for shelter. The number of cows is important. Too few cows will not give enough work to keep the dairyman busy nor yield enough milk to pay for investment in dairy barns, silos, and milk houses.

Dairying requires a high degree of management, and can be made profitable by a careful, diligent and skillful owner. It furnishes steady work the year around and a regular source of income. Prices for dairy products are steady and the farmer does not have so many elements of chance with which to contend as he has in other lines of farming.

A man with a dairy education has an opportunity to take good positions in creameries and milk stations, as well as on a dairy farm.

Grain Farming

27. On farms where large areas are devoted to the cultivation of single crops, such as wheat, corn, cotton and rice, the great aim should be to secure the highest profitable yield per acre. Drainage, fertilization, careful selection of seed, correct cultivation, and tillage, all phases of intensive farming usually can be applied to the grain farm with profit.

Fig. 26.—Drilling wheat.

A farmer who specializes in producing grain for market may be classed as a grain farmer. He would be considered as specializing in grain, if more than half of his farm income were from the sale of grain. Thus, if more than half of the income from farm products were from the sale of wheat, he would be classed as a wheat farmer, etc. Grain farmers are usually wheat or corn growers. Rice is another cereal crop to which some farmers have recently begun to devote much of their time and land. Where large farms of fertile land are held, with surrounding regions sparsely populated, systems of grain farming may prove profitable.

28. Wheat Farming.—The wheat farmer, like the stockman, has been, in a sense, a frontier farmer. Wheat is a suitable crop to grow a long distance from market, wherever fertile land is abundant and labor cheap. While the center of wheat production in the United States once laid east of the Mississippi river, the wheat region has been crowded westward by the small and general farmer until it now lies west of the Mississippi river. Any system of grain farming carried on exclusively must find its start in a fertile soil. The prairies of the Mississippi river valley were of this sort, but in the eastern part, by continued grain cropping, they became so depleted that decreasing acre yields helped the general farmer to wrest the land from the grain farmer, or forced the grain

Fig. 27.—Cutting wheat.

farmer to grow other products. So will the great wheat farms of the Dakotas and Kansas decrease in producing power until they can no longer compete with the crops of Canada, Argentina, etc. Then wheat farming will have passed from the United States. This does not mean that wheat will not be grown. We shall probably continue to grow as much or more wheat than ever, but it will be by more intensive methods, by fertilization and by putting the wheat in rotation on general farms.

(Copyrighted by Keystone View Co.)
Fig. 28.—Combined reaper and thresher harvesting wheat in the West.

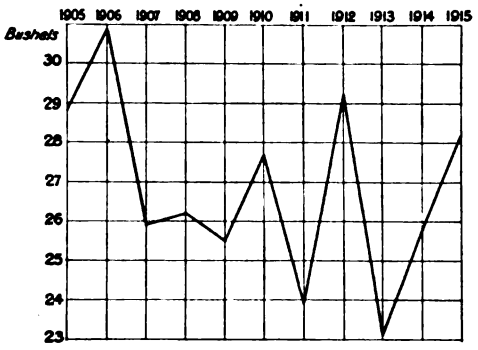
Already states practicing general farming and including wheat in their rotation are producing amounts which compare favorably with the states where the great wheat farms are found. The general farmer has less area devoted to wheat, the seeding of wheat costs more, and land is higher priced, but he usually obtains more wheat per acre than the large wheat growers. In general, it is considered better for the young farmer of today to take up the study of grain farming in connection with other crops and animals.

29. Corn Growers.—Growing corn for market year after year would soon deplete the soil fertility to the place where money required for fertilizer would be more than the profit realized from the corn. Formerly, as farmers began to homestead the central portion of the United States, corn produced abundantly without any consideration as to soil fertility. But the past fifty years of careless grain farming, induced by the introduction of farm machinery and a rapidly growing population, have brought us to a condition where, in places, the fertility element is vital and other crops and live stock must be grown, if farming is to be profitable. The acre yield of corn in the United States for the ten

Fig. 29.—A fodder cutter and loader drawn by tractor.

years from 1905 to 1915 is shown in Chart IV. During the period covered by this table improved machinery, seed, methods of cultivation, and more intensive practices have been continually introduced, but in spite of all these things the acre yield of corn has decreased. Continual cropping decreased the fertility so rapidly as to counterbalance any increased yield which should have resulted from improved methods. This chart shows strikingly why producing nothing but grain must be replaced by diversified farming.

CHART IV.—ACRE YIELD OF CORN FOR TEN-YEAR PERIOD.



It is only natural that live stock should be raised in connection with grain. The great demand for live stock and the advantages of marketing corn, oats, bran, and shorts, in the form of meat, rather than as grain, make it the obvious thing to do. Marketing live stock, instead of grain, leaves the fertility on the farm and with care will allow crop yields to remain high and even increase.

Fig. 30.—Husking corn.

(Copyrighted by Keystone View Co.)

Fig. 31.—Hoeing rice in South Carolina.

30. Rice Farming.—In the South Atlantic and Gulf States there is an abundance of land suited to rice growing. The rice farmer must be capable of living in a warm, moist climate and of doing heavy labor. The crop is profitable in parts of the United States even though it is produced in competition with the cheap labor of the Orient. Thirty

to forty bushels per acre is a fair yield and, besides this, the rice straw commands a good price as a winter roughage for range stock. It is superior to oats straw in this respect.

Market Gardening

31. Location of the Market Garden.—Market gardening, like dairying, is best located near cities, as the value of vegetables and berries depends largely upon the freshness of the produce when it reaches the consumer. Moreover, the successful garden demands fertile soil. Fertile soil near cities is high priced, but the market gardener practices intensive agriculture and can afford to pay high prices for land. Or, by heavy fertilization and drainage upon the right kind of poor land, a good market garden can be made, but this, likewise, is expensive. A man may work into market gardening gradually, using only a small plot of ground at the start. Many market gardeners make a living for themselves and families from less than an acre of ground. Market gardening is not an easy business. The competition is keen and the margin of profit small. Then, there are the risks incident to season, diseases, insects and glut in markets.

(By U. S. Department of Agriculture.)

Fig. 32.—A gardening scene.

Fig. 33.—Raising lettuce in a greenhouse.

Most of the work of the market gardener is not heavy, but is tedious hand work. The market garden requires more hand work in proportion to its size than any other kind of farming. A boy can do most of this kind of work, and, for the young man living close to town and having small capital, the market garden furnishes an excellent opportunity. However, more knowledge is required as the diversity of crops

is enlarged. Under intensive treatment, where every crop is being forced to its utmost, the plants must be handled exactly right and each in accordance with its own particular demands. It requires intensive efforts to make the market garden successful. On a large scale, a heavy expenditure of capital and labor is required and much depends upon the choosing of a proper soil and location. To succeed requires determination, intelligence and foresight. The truck farmer must grow, not only the crops in demand, but those which give the largest net returns for the labor. He must know the market and, above all, he must be a good salesman.

In the South, transportation facilities to the cities of the North and the demand for perishable vegetables out of season in these cities led many farmers to compete with the greenhouse enterprises of the North. Southern vegetables are now marketed regularly in the northern markets, when such vegetables would be out of season on the Northern truck farms. The gardens in the South can be occupied by crops the year around, and, if carried on in a large enough way, may be made quite profitable.

Marketing.—Success in marketing garden crops depends upon the location of the farm, the seasonableness of the crop, the supply for the market, and most of all upon the selling ability of the gardener. Usually, the most desirable marketing arrangement is direct to the consumer. When the produce goes through a number of hands, price to the producer goes down, the quality of the produce deteriorates in handling, and the price to the consumer goes up. Regardless of how vegetables are marketed, they should be carefully packed, and, if possible, delivered the same day they are harvested.

Fruit Growing

32. Fruit growing is as well adapted to intensive methods as any farm crop. Formerly, fruit trees were planted at random and nature was left to produce as best she could. Now, man assists the orchard yield in every possible way, the aim being to produce the largest quantity of the finest fruit it is possible to grow with profit. In the United States the apple crop alone is worth annually almost one hundred million dollars. This change from careless methods to highly specialized practices was brought about by increased demands for fruits, and the development of a ready means of transportation. The principal orchard regions of the United States are the light soil regions of New York, New England, New Jersey and the Great Lakes region,

Fig. 34.—Picking apples for market.

portions of the West and Northwest, the Ozark Mountain regions of Missouri and Arkansas, and the orange districts of California and Florida.

In choosing a location for a fruit farm, accessibility, soil, topography, and market conditions are important considerations. In growing fruits, as apples, oranges and grapefruit, good transportation service to market is important. If it were not for such transportation facilities, the orange and grapefruit production of Florida could not have been so well developed; nor could the oranges of California, and the apples of Washington and Oregon be sold regularly in markets 3,000 miles from the orchards. Since small fruits can not stand long shipments so well, they are produced as close to the market as possible.

The soil suitable for growing a desired fruit can only be determined with accuracy by actual trial as many factors enter into the determinations. The typical fruit soil of one region may vary materially from that of another region. For instance, the apple producing soils of New York and the Ozark Mountain region differ in origin, altitude and texture. In general, however, a fruit district should have a soil possessing the characteristics of good natural drainage, friability, and a porous, loamy subsoil, with freedom from hardpan or rock layers near the surface.

Fig. 35.—Fires placed to protect fruit trees from cold in early spring.

The fine fruit produced in the highly specialized fruit regions such as California, Washington, and Oregon has made the price

of these orchard lands almost prohibitive. Many such orchards are valued at over $1,000 an acre. They are a long distance from the Eastern markets, but the certainty of a yield, together with the fine quality of the fruit, give the orchards a high value.

Around most cities from the Mississippi valley eastward, there are farms well adapted to fruit growing. The moderate sized city is a fair market and the farmer in the region of the most attractive of these localities can make money from a well planned orchard, especially if berries and small fruits are also grown.

Orcharding is an attractive proposition. Trees in bearing are more profitable than field crops and usually less exhaustive to the soil. Very little fertility is removed in the fruit and much organic matter is returned to the soil by the leaves. The fruit crop increases in yield for several years after trees start bearing. Thus a six year old apple or cherry orchard would produce more than it would at five; and at seven years still more, etc. A five year old apple orchard, producing one box of fruit per tree, should, at the end of ten years, be producing at the rate of six boxes per tree.

(Copyrighted by Keystone View Co.)

Fig. 36.—Summer spraying in New York orchard.

Some of the greatest dangers to fruit trees are frosts, severe winters, and disease. Also, money must be invested in the fruit orchard for some time before returns begin to come in. In many regions marketing systems are poor and standards of uniformity lacking. Fruit growers' associations have done a wonderful work in the last few years in organizing the industry and putting the marketing on a business-like and profitable basis in the fruit growing regions.

Besides the actual fruit farming, special industries growing out of the products may be mentioned, such as canning, preserving, drying, and bottling fruit juices. All of these industries are of commercial importance in the United States.

On the home land is a good place for the boy to begin fruit farming. Grapevines, a few desirable varieties of fruit trees and berries

will give practical experience that can be applied later on a large scale, if desired.

Seedman

33. Seed growing as a branch of horticulture is rapidly assuming importance, although seed farms as a separate business did not exist in the United States until about 1784. By 1900 over six-hundred farms were devoted exclusively to this business and its growth since that date has been even more rapid. As farming becomes more complete and specialized, the general farmer does not try to produce seed for planting but leaves this branch of work to the seed grower. Much of the seed now used on the farm comes from seed farms. The work of producing pure bred seed of good quality requires a good agricultural education, much capital, and a great deal of careful hand labor.

Landscape Gardener

34. The artistic arrangement of plant growth in connection with houses, parks, and public buildings has brought into existence a demand for landscape gardeners. It is a vocation requiring knowledge of trees, shrubs and flowers, training in methods of setting and growing them, and artistic taste in their arrangement. This industry probably will never be of major importance, but positions are to be had at good salaries.

Floriculturist

35. The floriculturist sees to the taking care of flowers in parks, private grounds or in greenhouses. To make floriculture pay demands much capital for greenhouses, heating systems, and high priced ground, if the business is to be located near a good market. Usually, if the market is a good one, competition from other men who have established their trade will be keen. The beginner with limited means had best start in a well-conducted and paying establishment and work for a time to gain a practical knowledge of the business.

36. **Nurseryman.**—The nurseryman is a specialist having possibilities limited only by his aptitude, capital and business ability. The nurseryman, like the stockman or plant breeder, largely raises products which others utilize before the ultimate agricultural product is obtained. The trees he raises are early taken to all parts of the country to be cared for and brought to maturity. Nursery stock includes almost all kinds of horticultural plants. The branches of the work are so varied that only the biggest nurseries, with large capital, can undertake all of them.

A good way to begin work as a nurseryman is as a workman in

a large nursery. This work should follow a course in college, if possible, and should be supplanted by reading books and bulletins on the subject. Later, experience gained may be applied on a plot owned by the worker.

Cotton Farmer

37. Cotton is the most important fiber crop in the world, and nearly eleven billion pounds of clean fiber are produced annually. Of this total the United States produces about seven billion pounds. More than half the crop of the United States is exported, and more money is obtained for it than for any other class of exports.

A desirable cotton soil is a well-drained rich deep loam. The most favorable season is a relatively dry spring with warm weather, followed by abundant summer showers and a dry fall. The leading cotton states in the order of their production are: Texas, Georgia, South Carolina, Mississippi, Alabama, North Carolina, Arkansas, Louisiana, Tennessee, Florida, Oklahoma, and Missouri. It has recently been successfully grown in Arizona, Northern Utah, New Mexico, and Southern California.

(Copyrighted by Keystone View Co.)

Fig. 37.—Picking cotton.

The tendency at present is to diversify farming in the cotton states by growing oats, legumes, corn, etc. The all-cotton system of farming was never really successful under any conditions. Cotton farmers often claim that it is more economical to grow cotton exclusively and buy all supplies for the farm. The correctness of this claim has not been substantiated. Even at the high price of cotton for the past few years the man who grew it made little clear profit unless he grew part of his supplies. Statistics show that the men who succeed do not grow cotton exclusively. The actual time devoted to growing and gathering the crop on the all-cotton farm is not more than six months. This leaves hands and teams practically idle for the other six months. Unless there is some practicable labor furnished during this time, the additional expense must be taken from the proceeds of the cotton crop. The small farmer or tenant will never be able to get much more than a living out of cotton, when he buys everything else used on the farm.

Providence has given the Southern United States the ideal cotton belt, and the cotton farmer need not worry about Africa, Egypt and other countries furnishing the world's supply and destroying his business. The worst difficulties of the cotton farmer today are, cotton disease, the boll wevil, and problems of soil fertility.

Poultry Farming

38. The work of the poultry farmer is light but requires knowledge and careful attention to details. It does not require much capital to start the poultry farm in a limited way and, if properly handled, the steady income will soon enable the beginner to enlarge his operations. The poultry farmer can specialize in different directions, as raising frys, or breeding stock, and in egg production. All of these phases can be combined to some degree, but the best breeds for meat production are not best for egg production, although they will aid the income in that respect.

Fig. 38.

The profits from egg production are obtained chiefly by supplying a select trade with strictly fresh eggs. A good price can be obtained in this manner, and a profit secured which cannot be made by selling eggs on the general market. The general farmer sells eggs of any quality, in any condition, and the great loss which is caused by the perishable nature of the eggs keeps down the price. Selling eggs as a business in competition with such farmers cannot be profitable unless a higher price is obtained.

Fig. 39.

The loss due to careless methods in handling eggs must be suffered by the producer and the amount is exceedingly large, averaging possibly forty-five million dollars annually in the United States. It is estimated that eggs and poultry produced on the farms reach a value of $650,000,000. The loss, due to bad eggs alone, is seven per cent of the entire product. The poultryman marketing at regular prices must help shoulder this loss.

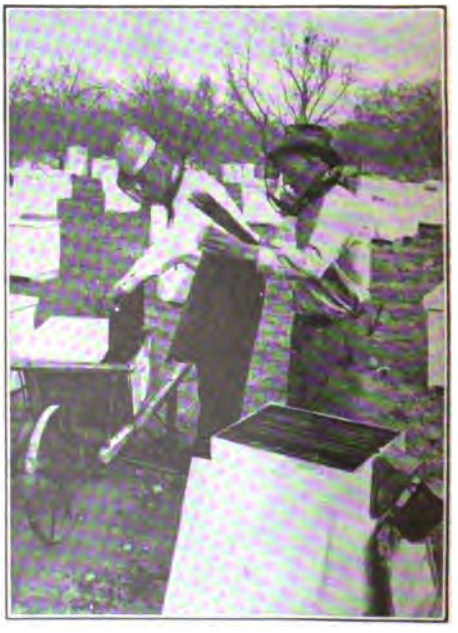
Modern developments have placed many exclusive egg farms in the thickly populated regions. Many of them have from two to fifteen thousand layers. However, poultry as an exclusive farm business is usually an unprofitable venture for any but those having had a great deal of experience. While there are many large poultry farms operating at a profit, yet the larger part of our poultry is produced by those who raise poultry as a branch of general farming. It is advisable to begin in this way. As experience is gained and the profitableness of the industry becomes apparent, more attention can be given this work.

39. The Poultry Fancier.—The poultry fancier needs to invest both time and money in selecting, breeding and improving his birds. The successful poultry fancier must have training, experience, good business ability and capital. He must also be a good salesman.

Poultry keeping has the advantage that it does not require much land, the products can be readily marketed, the work is light and suited to both men and women, the income is steady and certain, and with care the profits are reasonably large.

Bee Keeping

40. As a rule, bee keeping is not the sole occupation of the man who has bees. There are, however, many places where an experienced bee keeper can gain a good livelihood by devoting his entire time and attention to this work. Considerable previous experience on a small scale should be had before undertaking extensive bee keeping. The work requires knowledge and patience in caring for many minor details. Few lines of farming require more study to insure success, as the profitable manipulation of bees depends upon a knowledge of their needs and habits.



(Copyrighted by Underwood & Underwood, N. Y.)

Fig. 40.—A modern aplary in western Texas.

Little capital is required at the start. One or two hives and

a few dollars worth of equipment is sufficient. Properly handled, in a successful year, a hive of bees will pay for itself.

The business has the disadvantages that it requires much detailed labor and there is, at all times, danger of contagious diseases. These diseases once started are hard to control and soon lower or entirely destroy the profits.

LUMBERING

41. The industry which ranks second in America's great list of producing agencies, the lumber industry, is waking from a long sleep and with giant strides is endeavoring to catch up in point of efficiency with industries of lesser importance which long ago were brought up to modern standards.

It has been said that the lumber industry has long been among the most efficient, up to the point of finished manufacture. From that point on, through the process of merchandising, it has been far behind many of the rest. This charge is being discredited by recent developments in lumber merchandising.

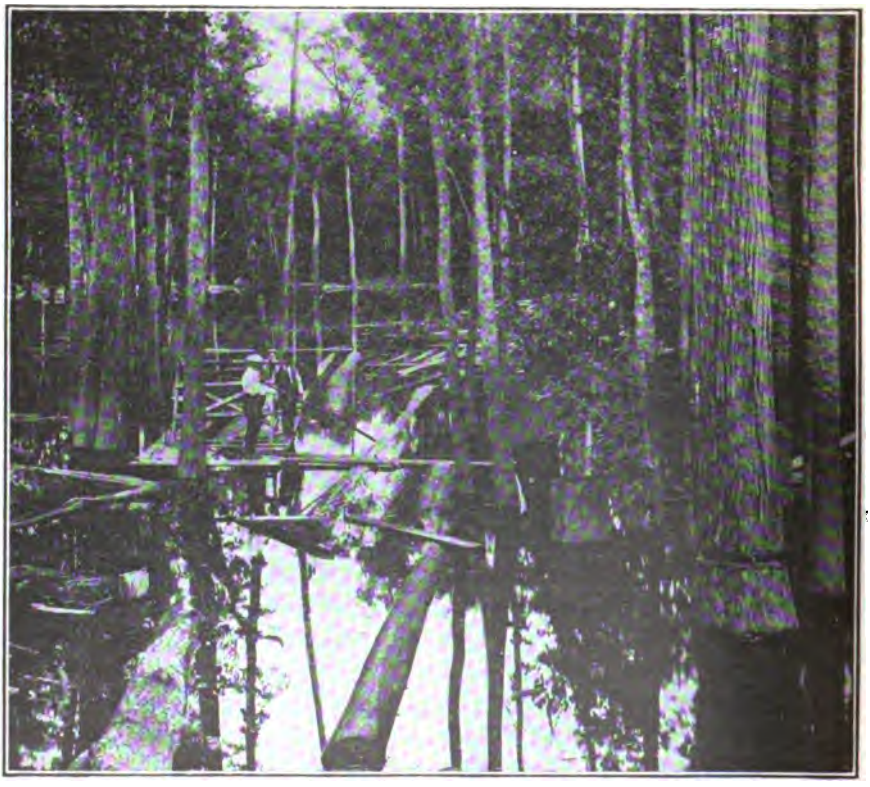
Probably few realize the magnitude of the industry. According to a recent report of the United States government, logging and lumbering operations of the United States represent an invested capital of $2,500,000,000, and employ a force of 900,000 men. The annual value of the products of the 49,000 saw mills of the country reaches the enormous total of $600,000,000.

There has been a feeling among the public of the United States generally that a timber famine was pending and that the end of our forest resources was in sight. Such, however, is not the case, for an investigation by the Bureau of Corporations of the United States Department of Commerce reveals the fact that there are now standing in the United States nearly 3,000,000,000,000 feet; so, not considering new growth, it is seen that the present forest resources will furnish adequate material for the next sixty years. In view of the fact, however, that our per capita consumption of lumber is decreasing, and, if we consider a normal increase in the supply due to the growth of new timber, it is very probable that if we never plant a tree, the forest resources would take care of our wants for the next hundred years.

Lumbering operations may be divided into two main divisions: logging and saw milling. Logging is the business of felling trees and transporting them to the mills. The usual division of labor in logging operations are given in the following pages. A discussion of the duties of the more important positions is also given.

The organization and work of the men in the yellow pine regions of Louisiana, Mississippi, Texas, Arkansas, Virginia, etc., is as follows:

General Manager.—The **general manager** has charge of the entire logging camp and is at all times in direct touch with the location engineer, woods foreman, trainmaster, assistant manager, land agent, log scaler, chief clerk, and storekeepers. He is responsible to the officers of the company for the results obtained. He is the most important person directly connected with logging operations and holds a very responsible position. He must be a good business man, a worker, and a leader of men; he must be a man of action, a



(By U. S. Forest Service.)

Fig. 41.—Lumbering cypress in Georgia.

quick thinker, and he must know timber methods. Above all he must be reliable. Such a position requires experience as well as education, but the nature of the work and the remuneration make it a very attractive position. The large privately-owned timber tracts are held by few concerns and not many positions of this kind are to be had.

Before logging begins, a survey of the timber must be made, the **land agent** directing the work, and purchasing desired tracts. He is guided by the work of the **timber cruiser** who goes through the woods studying the kind and character of the trees, the lay of the ground, and natural facilities present for getting out the logs. Acting upon the timber cruiser's reports, the land is purchased and preparations made for logging. Topographic maps are made in connection with the timber cruise which are used in laying out the roadbeds.

The **location engineer** lays out the roadbed, first for the main line railroads and then for the spur tracks. Pole roads were formerly used by lumbermen, but they were primitive in character and are now seldom used. Stringer roads took the place of pole roads and light locomotives largely took the place of horses. Later, steel rails took the place of stringers in most places. Rail transportation is the most desirable method for transportation, except where conditions are exceptionally desirable for floating by water. The spur lines can be built with less care and expense than the main line, and, aside from their layout, do not demand so much skill on the part of the engineer. The main line of a logging railroad is of great importance, because the engineer must preserve a proper balance between cost and operating expenses. He must avoid steep grades, long hauls, sharp curves, high water, etc. The laying of main roads demands careful attention of the engineer while the spur roads which are rather temporary, and located with especial reference to the timber, may be located by the woods foreman.

(By U. S. Forest Service.)

Fig. 42.—Using oxen in lumbering tulip tree in North Carolina.

The location engineer should be an expert logger. Good civil engineers, without logging experience, are usually failures at logging railroad work, because of many peculiar problems which they have never met. Expert logging engineers can find continuous employment, although the field of work is not large. The work is arduous, and healthful and the pay is good.

The engineer is aided in locating the roadbed by one or two **rod men** and **axmen,** the number depending upon the thickness of the brush.

When the work of preparing the roadbed is started, the **grading contractors** take charge of the work under direction of the location

engineer. The grading contractor prepares the roadbed from a month to a year or more in advance of the logging operations. He has common laborers of various sorts under his command. The right-of-way crew fells the timber, removes the stumps and cuts the brush for skidways. The timber cut is used in building the roadbed, culverts, etc. Cuts are made, where necessary, and the earth removed and used for fills in low places. This requires blasting, picking, scraping and shoveling, the work being done by teams and common labor. In places, it is necessary to build trestles and bridges, which requires the work of carpenters. Ties for the roadbed are cut by an expert "tie hacker." He becomes skilled by practice, but the pay is not large. While these operations are under way, the camp is constructed. In early times, camps were crude, illkept structures, where poorly prepared food was served, in a most unattractive manner. The modern logging camp is clean, well ordered, and furnishes a wide range of wholesome food. The camp usually consists of one-story log buildings, including bunk houses, a cook shanty, an office building, storehouse, stables, and a blacksmith shop.

The **woods foreman** has charge of all active logging operations, including cutting and getting the logs out ready to load. He has directly under his charge the logging boss, notcher, team boss, and camp blacksmith. He should be a good leader of men, vigorous, active, and a quick thinker, and must have a knowledge of logging operations. His work is strenuous and his responsibility heavy. His pay is good.

The trees for felling are marked by the **notcher** and cut by **sawyers** who work in crews of two. The sawyers also cut the trees into logs. **Swampers** cut off the limbs and clear roads so that teams can drag out each log. The **camp blacksmith** keeps all tools sharp and in repair. He receives good wages, but must work long hours during the busy season.

(By U. S. Forest Service.)

Fig. 43.—Teams snaking logs in an Idaho yard.

After logs are placed on the skidways by the teamsters, the **log scaler** measures each log and records the timber taken out. This record goes directly to the office and is used as a basis of payment, if the lumber is being taken out under contract.

The **trainmaster** has charge of the trains, roadbed and all

loading operations. He is directly in touch with the spur grading boss, loader, engineer, train conductors, and section boss. The **grading boss** has charge of the roadbed on the spur roads. The **loader foreman** has charge of the loader crew.

Most cars are now loaded by machinery. Such a loader is shown in operation in Fig. 44.

Another crew of men is engaged continually in moving tracks and building new lines. This crew may consist of almost any number

(By U. S. Forest Service.)

Fig. 44.—Loading logs with steam loader in Arizona.

of men, usually varying from ten to twenty-five. The **train conductors** have charge of the trains. The **section boss** has charge of maintaining the condition of the tracks. The work of his crew is heavy, as the track is usually subject to many hardships, as heavy traffic, poor roadbed, high water, and bad weather. The section crew is quite variable in size. The section boss must be a leader of men and experienced. He receives fair wages.

Most large companies have their own storerooms carrying tools and equipment. A man is constantly in charge of these stores. Also supplies are kept in a company store for the convenience of the men. They can purchase from the store against wages due them and are usually glad to avail themselves of this credit.

In the general manager's office is the **chief clerk** who has charge of the office force. He keeps trace of all material, both incoming and outgoing, prepares the payroll, and looks after the company records.

After the logs reach the mill, all operations are under the supervision of the assistant manager.

The **assistant manager** has direct charge of the sawmill foreman, yard foreman, dry kiln foreman, supply clerk, head carpenter, shipping clerk, and planing mill foreman.

In the Northern woods, lumbering is carried on by a slightly different organization, as the lumber is usually floated out.

The general manager is at the head of the work and has the same duties and responsibilities as in the Southern camps. He has directly under him the same men as the Southern foreman, except that he ordinarily has no railroads to build, but has, instead, a drive foreman who directs the floating of the logs to the mills.

The woods foreman has charge of all work in the woods until the logs are ready for the drive. He has charge of the scaler and clerk, saw boss, road foreman, toters, cook, skidding foreman, road repair men, and landing boss.

After the survey has been made, and the cruiser has submitted his maps and report, the tote road to the camp site is built. This road is not used except to transport materials and supplies to the camp site. It is the only avenue of transportation between the camp and civilization. The camp is similar to a Southern camp in its layout but from necessity is better built. The office is occupied by the foreman, scaler and clerks.

(By U. S. Forest Service.)

Fig. 45.—Felling a red pine in Minnesota.

After the camp is constructed, and before winter sets in, the main road over which the logs are to be transported is built. This road is as important as the main railroad in a Southern camp, and much labor is spent on its construction and maintenance. It must be in good condition at all times and a gang of road builders is kept busy at work. At intervals along the roadway, swampers clear square spaces called skidways, for piling the logs. Also, the swampers cut narrow roads to allow teams to pull out the logs. Finally, the saw boss and his crews, preceded by the swampers, begin the actual felling of the trees. The sawyers cut the fallen trees into log lengths and the skidding boss with his crew drags the logs to the skidways, where they are piled to await transportation to the mills. This assembling

of logs at skidways or yards preparatory to hauling is called skidding.

Skidding is accomplished either by the aid of animals or machines. Where the distance to the skidways is short, the logs are snaked out with horses. Formerly oxen were used for this purpose, but they have been largely displaced by other sources of power. Stationary engines are coming more and more into use for snaking out logs. Fig. 46 shows a donkey engine snaking a yellow pine log. The teams shown in the background are to snake the logs from the donkey engine to the landing. In the South, some companies snake logs by means of "aerial tramways," run by stationary engines. The piles of logs are scaled as previously mentioned and are then ready for transportation. The transportation of the logs to a stream or to the mills is termed hauling.

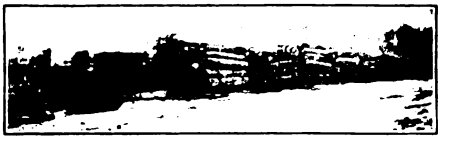
(By U. S. Forest Service.)

Fig. 46.—Donkey engine snaking logs in California.

(By U. S. Forest Service.)

Fig. 47.—Three sled loads of red and white pine.

In many forests of the North and West hauling is accomplished by means of steam engines. Such an engine is shown in Fig. 48. The engine is steered by the runners in front and the traction secured on the broad surface of "caterpillar feet" under the rear. Such engines on smooth roads pull almost unbelievable loads. The one shown here is doing the work of 12 teamsters and 48 horses.



(By U. S. Forest Service.)

Fig. 48.—Steam log hauler.

In the northern woods, the logs remain on the skidways along the main roads until deep snows fall, then the hauling begins. The main road is smoothed down, sprinkled with water from a sprinkling tank, and grooved for the bobs. Constant going over the snow road works it down to a perfect sheet of ice with tracks for the bobs so smooth that great loads of logs weighing as high as thirty-five tons

may be taken with almost no power down this ice road. Driving the sleighs or bobs is a hazardous business, dangerous alike to man and animals. It requires constant work to keep the road in shape, as it is used continuously until the spring thaw or until all logs are out to the landing.

(By U. S. Forest Service.)

Fig. 49.—A log drive.

Landing bosses have charge of placing logs on the temporary storage grounds. These landings are made along the banks of streams. The logs are scattered as much as possible, depending upon the size of the stream, number of logs, the thickness of the ice, and the height of the average flood water. All these things are problems of the landing boss. He needs to be experienced from years of work for the job. It is often necessary for the logs to be "decked" in immence piles, often entirely across the river.

When the spring thaw and flood comes, the logs are carried down stream to the mills. Transportation of logs down stream is called "the drive" and is more difficult and dangerous than it would seem. The **drive foreman** who has charge of this work has under him a crew of drivers who perform many hazardous tasks. They work long hours, under all kinds of dangers and hardships. Their task is not enviable. When a number of companies are driving down the same river, the logs become mixed and the drive becomes the work of the combined crews. Men are stationed at all places where logs might lodge to keep them pushed into the current. A single log lodging might, if left, start a "jam," piling up millions of logs. Sometimes when jams occur, dynamite has to be used to start them. Getting the logs started is a very dangerous job. Men follow along the rear of the drive prying into the current any logs left or lodged until finally the entire winter's cut is caught at the mills by a boom. A boom is a chain of logs stretched across the river usually in a quiet

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Fig. 50.—A huge log raft in process of building in the state of Washington.

place or mill pond. See Fig. 51. Here the logs are sorted. Each log has a mark on it designating to whom it belongs and the sorter steers it into its proper boom. After each owner has his logs in boom they are ready to go through the mills.

The demand for lumber has caused great industries to come into existence and has stimulated advanced methods of lumbering and milling. The industry today is highly specialized and work is done on an elaborate scale.

About one-fourth of the timberland of the United States has been set aside as state and national forests. It is the work of the Forest Service to put into execution the regulations prescribed by the United States Government for cutting and handling of timber in these forests. A few years ago the young man trained in forestry would have found little demand for his services. Now the government, as well as large private corporations, are demanding foresters, to appraise the forested area and consider means for utilizing the cut to the best advantage. Besides, much is being done in the way of conservation, under foresters' directions, such as, so manipulating the cut as to get a second cutting in 20 to 30 years. The work of the forester in the field is arduous, but the outdoor life has many attractions. The pay is not large compared with other occupations requiring a college education, which a forester should have.

42. Sawmilling.—Next comes the real lumber manufacturing process. While a great deal of labor has been expended on the logs, they are still logs and until they pass through the mills are of little value to man. These huge mills, to supply the enormous demand for varied lumber products, must be located within easy reach of both the logs and the market. So, adjoining the heavy timber regions in places accessible to cities by means of rail or water are located the greatest saw mills in the world, capable of turning millions of logs into highly valued products in an incredibly short time. Logs are fed in at one end of these mills and lumber products come out at the other end ready for the needs of industry.

(By U. S. Forest Service.)

Fig. 51.—Log pond and mill.

After logs are stored in the yard or mill-pond, they are under the supervision of the saw mill employees. The out-door men who first

Fig. 52.

handle the logs are the **log-yard boss** and his crew. The log-yard boss gets logs to the saw that are suitable for the particular order being cut and does the work efficiently. His knowledge is largely the result of experience and practice. The crew under his supervision become skilled in moving the heavy logs, but other than this skill require little ability. They must be strong men physically as the work is heavy.

At the other end of the mill is the **lumber yard boss,** and his crew. This crew consists of **sorters, graders, stickers, kiln men** and general laborers. The lumber yard boss and his crews may be loading green timbers for shipment, stacking lumber for air drying in the yards or docks, filling and emptying dry kilns, sorting, grading and loading seasoned lumber for removal, all at the same time. This diversity of work may require several men, depending, of course, upon the amount and nature of the output of the mill. In the largest mills, this work may be divided, a grader, loading superintendent, kiln boss, etc., all working under the supervision of a general superintendent. Most of the work is done by unskilled laborers.

Fig. 53.—A modern mill yard.

In the mill, there is the same or even a wider diversity of work. Next to the general superintendent, the **head sawyer** is the most important man in the mill. He determines how each log shall be cut, what it will make, and controlls all the sawing operations. Upon his skill largely depends the value of the lumber obtained per log and the number of board feet cut per day. The head sawyer is the best paid man in the mill, as a rule. He is paid for his knowledge more than for the actual labor performed. In the older type of mill, using the circle saw, he did much of the work, helping with the edging, adjusting the carriage, etc. In the modern band-saw mills, using also gang saws, his services are more important in directing the work. The modern band-saws run at a tremendous rate of speed and are capable of cutting thousands of board feet an hour. More recently, gang saws have come into use enabling a number of boards to be cut simul-

taneously. In such mills, a log never stops in the mill. Without a pause, it is rolled, carried, squared, ripped into boards and timbers, smoothed and delivered onto waiting carriages as finished lumber ready for seasoning.

As each slab, board or timber leaves the saw, men called **offbearers** direct it toward the place where it is to receive the next operation. Formerly the offbearer carried the timber away from the saw and from this task he obtained his name. Now rollers, revolving in one direction, carry the pieces away from the saw and the offbearer has only to keep them moving. The slabs go to the **cutoff man** who takes them from the table and places them upon his saw table. His saw is

(By U. S. Forest Service.)

Fig. 54.—A large mill with usual output of 200,000 feet per 10 hour day.

movable, or in some cases the table is movable and the saw is stationary. With this cutoff saw, he cuts the slabs into lengths suitable for laths, pickets, shingle bolts, and firewood, getting from the slabs whatever he can in the way of usable material. The wood is thrown on an endless belt, carried to the outside of the mill and left in the mill yard without further attention. Cutoff men, like the sawyer, are men of good judgment and upon their ability depends the amount of salable material other than wood obtained from the slabs.

As it passes along, each piece that can be made into a board is taken from the rolls by **edgers.** These men pass the pieces through a machine called an edger which has adjustable saws and can be

quickly set to cut off the rough edges, thus making a board. Edgers require no special skill but experience enables them to work with speed and with little waste of material. As the boards come from the edgers, they are taken by the **trimmer.** His task is to operate a "jump saw," which cuts the boards to the required length. Trimmers also operate a "butting saw," which is used in cutting heavy timbers to length. Trimmers and edgers are the last men to work on the board in its progress through the mills and from their machines the board travels at once to the outside men, a completed rough board.

For operating the machines in the lath and picket mill, no particular training is required, except experience in handling the machines. Usually two men are assigned to each saw, one man feeds the lath stock into the saw, and the other returns the uncut portion to be sawed again, at the same time removing from the saw table the lath or picket cut. Counting and tying bundles of laths preparatory to shipment furnishes labor for a number of individuals. The dust, the noise, and the monotony of the work make it unattractive. However, unlike much mill work, it is not heavy labor.

A majority of our homes from coast to coast, are covered with shingles. Shingles are cut from shingle blocks by workmen operating a "shingle mill," also called a shingle riving-machine. Other men put the shingles through a shingle jointer and shingle planing machine, finally turning out completed shingles. Men who work on these machines become expert at the work and from material that might otherwise be wasted turn out millions of dollars worth of shingles. Making shingles by these machines, turning out millions of "squares" each year is quite different work from the old method of splitting (called "riving") shingles by hand with a broad ax. Men now turn out uniformly tapered shingles of a standard length, where by hand, the thickness of the shingles or clapboard as it was called, was the same from end to end and varied with the taste and ability of the workman.

Fig. 55.—Dressing room in large mill.

Besides the men mentioned, in the saw-mill there are engineers, firemen, saw-dressers, general laborers, and repairmen. The **saw-dresser** is one of the most highly skilled and best paid men in the mill. Caring for the highly tempered steel saws requires special skill. The saw-dresser sharpens and sets dull saws, welds broken

ones, and by hammering trues up those which are out of line or balance. Where special cutting machines, as planers, are operated in connection with the saw mill, the saw dresser has to sharpen the edge tools and drill bits. Usually the saw dresser has several years of practical experience before being permitted to take charge of the work. His work is light, when things are going well, but a few stones or spikes imbedded in a log may give him much work to do. A good saw-dresser is invaluable to the saw mill, and, as so much depends upon his skill and knowledge, excellent wages are paid. The long apprenticeship necessary for this work makes the number of saw-dressers few. A man may read how to hammer a saw and learn all the principles involved but the first saw he hammers probably will be ruined. Experience is the only adequate method of becoming efficient in this work.

43. In connection with the big saw mills, men are employed to operate the **planing mills.** The chief object of these mills is to remove all surplus material from the board, to reduce the bulk and, consequently, the freight charges. The most important result is the smooth surface produced. Mills plane the stock on from one to four sides but the usual plan is to furnish the lumber S2S from the mills. Huge power machines with revolving knife blades running at a high rate of speed are used to plane the boards or timbers. Once started through the machine, the piece is automatically fed through by a set of rollers. The modern machines are designed to plane any number of sides, all four if desired, at the same time. The men operating the planers need no particular skill to run the machines, other than to know how to adjust them. But they must be good mechanics to keep the pulleys, shafting, belting, planer blades, rollers, and gauges all properly adjusted and working. The knowledge needed may be readily gained by experience.

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Fig. 56.—Dressing big pieces of lumber in Puget Sound region of Washington.

44. **Resawing** is another task for the planing mill men. They resaw boards by passing them through a set of rollers standing vertically and parallel to a band-saw. As the board is fed through the rollers,

the saw rips the board. An ordinary band-saw may be made to do resawing by adding this attachment. The only skill required of the resawer is in adjusting the machine and the mechanical ability to keep it in shape. As a rule, the work in the planing mill is monotonous and not of a nature to be attractive as a life's work. Foremanship in the planing mill is a desirable position, but the chance of becoming a foreman is small. This work is a good preparation for higher positions in other fields demanding a thorough knowledge of the properties of lumber.

45. Veneering.—While large saw mills may have veneer mills in connection with them for utilizing material that might otherwise be wasted, as a rule, veneer is made in separate mills, or in connection with the furniture industry. Men make veneering material by revolving a log against a knife, which is as wide as the piece of log is long. Their machine is really a monster lathe, which revolves the log against a wide, heavy, highly tempered, and carefully sharpened knife. The depth of the shaving which the knife is set to cut is regulated by the operators and as the work proceeds the log is unrolled as if it were a roll of paper, and enough material often obtained from a single log to cover thousands of feet of less beautiful material. The men are so expert and the machines so accurate that veneering may be readily cut as thin as 1/16 of an inch. The precious woods may be cut even thinner than this, some of it not much thicker than heavy paper. Many men are employed in the mills to cut up the veneer, attend to gluing-up presses, glue spreading machines, and core cutting machines. The work in the veneer mills, unlike the work in the saw mills, is light work, dexterity being required of the successful workmen rather than strength.

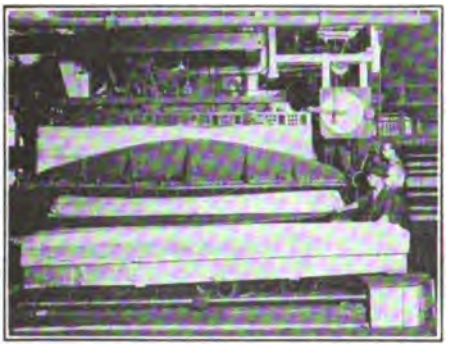

Fig. 57.—A veneer machine.

FISHING

46. Fishing, like mining, removes material from its natural home with no attempt at replacement. Fishing companies want dividends; captains, mates and crews are paid for results and, consequently, they capture all the fish they can, regardless of the probable effect upon the future supply. In their operations many young fish are destroyed,

many are taken as they are making their run to the spawning ground, and much spawn is destroyed after being deposited. These problems are among the most important economic problems of the future fishing industry, and should be kept in mind throughout the entire discussion. It is doubtful if the fishermen are to be blamed. They have a hard life and one ill-suited to any except the most hardy and strong. From skipper to ship's boy, they all carry their lives in their hands, with no comfort in repayment. Their hours are nearer eighteen than eight per day and their pay almost in an inverse ratio to the hours. The future will certainly see more attention and better prices given to fish products and producers.

The fisheries of the United States produce annually 1,500,000,000 pounds of food fish, exclusive of the large amount obtained from Alaskan water. The chief food fish are cod, herring, salmon, halibut, and mackerel. The annual catch of oysters is also of much value. Hundreds of thousands of people are engaged in the fishing industries, the United States alone giving employment to almost 200,000 people who produce an annual catch valued at more than $55,000,000. On the Atlantic coast are found valuable fishing grounds abounding in cod, halibut, herring, mackerel, haddock, oysters and lobsters. The Great Lakes yield trout and whitefish. Salmon fishing is one of the most profitable on the Pacific coast.

The largest catches in the United States are obtained along the New England States. It was chiefly the great abundance of excellent sea food along the coast that enabled English and French colonists to become established. Since that time to the present, the industry has greatly improved and enlarged. The growth of the industry has been due more to the perseverance and skill of the fishermen than to improved methods or equipment.

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Fig. 58.—First catch of the season.

The captain or skipper of each boat putting out to the fishing grounds is an expert sailor. He knows navigation, the fishing grounds, and weather conditions as well as the merchant knows his goods. Indeed it is upon his knowledge that the success of the trip and the lives of the crew

largely depend. As both he and the crew are paid usually in proportion to their catch, they take the keenest interest in their work.

47. Cod fish are migratory and travel in large shoals. They are one of the leading sea fish and are taken in great numbers along the New England Coast. They have been caught in enormous quantities for the last 200 years and more, but there seems to be no decline in their abundance. Cod are caught both in nets, and on hooks and lines. In line fishing, a trawl schooner or similar boat with its crew puts out to the fishing ground. Here the crew splits up in pairs, each pair having a small boat or dory and one or more set-lines. These lines are long and heavy and have shorter lines, each carrying a hook, attached every few feet. The hooks are baited and the long line sunk, or shot as it is called, across the tide. One man in the dory rows while the other passes out the baited line. After the line has been out for some time, usually ten to twelve hours, it is reeled in and the fish taken to the mother ship. Each single line carries more than 100 hooks and sometimes they are tied together until the hooks number five or six thousand, the line being five or six miles long. In good times, an average of fifty fish to one hundred hooks may be obtained.

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Fig. 59.—Drying codfish in the sun.

The cod fish are preserved by cleaning, salting and drying. The fish are dressed by a number of men, first being laid open across the throat and ventral side by a man called a **cut-throat.** They are then passed to the **header** who saves the liver and throws aside the viscera. The offal is used to make fertilizer and glue. The fish are next passed to the **splitter** who cuts out the backbone nearly to the tail. The splitter commands the highest wage of any of these men, as his work requires quite a little dexterity. Next, the **salter** washes the fish, salts them, and piles them up for drying. When the large heaps become dry to a certain degree, they are ready for storage and market.

Fishing with nets is the most efficient, but many vessels use lines. This is due largely to the fact that it requires less capital. When the fish are fat, they do not feed well and then the net fisherman is the only one that makes a catch.

48. The **mackerel** is one of the important fish in our market, particularly during spring months when it migrates northward to spawn. Its habits are quite irregular and it is hard to catch. In a good year, they are profitable to the fisher and it is this hope that causes the mackerel fleet to continue to exist. The new mackerel boats are of the best construction and are the most modern of power fishing boats. Each member of the crew has an attractive berth, and the cook furnishes the best of food. Mackerel swim in shoals and are captured by the drift net, the seine, and hand lines. In using lines, the boat is kept moving and each man runs two lines, each with a single baited hook.

49. The **tunny fish** is the largest species of the makerel. It is present in all warm seas and attains a length of ten feet and weighs as much as 1,500 pounds, although this size is probably the maximum, and most of them weigh much less. Tunny fish are captured in nets and sold both fresh and canned. It is an excellent food fish and the canned product is finding much favor.

50. **Herring** are a migratory fish of even greater importance than the mackerel. Unlike the mackerel, they are cool water fish and reach their greatest development in the region of the Arctic circle. The eggs of the herring sink to the bottom of the sea where they hatch. The fish are taken almost entirely in drift nets. Each boat carries a fleet of nets for the drift fishing, and may consist of any number from twelve to a hundred. Sailing boats, called sailing drifters, need a steady breeze to work these drift nets, but the steam-drifters now being used can fish independently of the wind. Herring fishing is profitable, enormous numbers being taken during the winter months. The herring runs little chance of exhaustion by continued fishing. We need not study how to save them so much as how to capture and use them economically.

51. As previously stated, fishing is a hard and dangerous life. The skipper and mate are paid wholly by results. The cook is next in importance and receives a definite wage. The engineer and deck hands receive fixed wages.

Some companies send out their boats on a share plan. By this plan, after all expenses are paid, the profits are divided.

The ideal method is for the men who form the crew to supply the capital and share the results, but the men seldom have the capital. As fishing is the most uncertain of all industries, even this plan has its disadvantages.

52. The most valuable commercial fisheries in the world, excepting only the oyster and herring fisheries, are those supported by the **salmon.** Of these, the most important by far are the salmon fisheries of the Pacific Coast of North America, where California, Oregon, Washington and Alaska, including also British Columbia, possess industries representing millions of dollars of investment and millions of output annually. The Columbia river has produced more salmon than any other river in the world and in 1915 there were nineteen large canneries in operation on the river. Salmon range in size from eight to sixty pounds and occasionally specimens are taken weighing more than 100 pounds.

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Fig. 60.—Canning salmon.

Large quantities of salmon are also frozen, mill cured, pickled, smoked, and sold fresh. Most of the catch is obtained by pound-nets, gill nets and drag seines. The native-born American is not often found actually engaged in fishing, but frequently is the owner of the fishing gear or has a responsible position in the packing plants. Any individual having a small amount of capital can purchase fishing gear and boats and start into the fishing business, a ready market being found at the canneries. Most fishermen work for the canneries, the owners of the cannery furnishing the equipment, and hiring the rivermen at fixed rates. While the fishermen usually have regular wage understandings with the company, the pay as a rule is small. Commercial fishing begins as soon as the fish start to move from the ocean, up the stream to spawn. This movement is called a **run.** The Columbia river has three runs of salmon each year, the first during January, February and March; the second, which is the best run, during May, June and July; the third during August and September. The remainder of the time, the canneries are closed.

The canning of salmon employs a large number of persons, some of whom must be skilled. The work is largely coming to be done by machinery. When salmon canning was in its infancy, a pack of 200 cases was considered a good day's work. Now it is not uncommon for a single cannery to turn out 4,000 cases in one day.

The fishing crew sell or deliver their catch to the cannery vessel, called a cannery-tender, and from this vessel the fish are at once delivered to the cutting room of the factory. In the cutting room,

the fish are first dressed either by the dressing gang or by machinery. While the work was performed by hand a few years ago, it is at present largely done by machinery. Next, the fish are passed through the cutting machines, which cut the fish transversely in sections, the exact length of the cans to be filled. One filling machine will fill cans at the rate of 80 per minute. Each can is automatically removed from this machine and weighed. Those under weight are removed and repacked by hand. The others pass on to the capping machine. The cans are topped and soldered by machinery. Next, the cans are cooked in large retorts under a pressure of six to twelve pounds of live steam. The cooking usually requires about seventy minutes. The cans are cooled and inspected for leaks or dents. Those damaged or leaking are resoldered by hand and again "processed" or cooked. Finally the cans are cleaned and lacquered to prevent rusting, labeled, and boxed. The cleaning, lacquering and labeling is now done largely by machinery. The operating of all this machinery requires men who are skilled mechanics.

53. **Sardines** were first found in large shoals near Sardinia, from which they derived their name. At present many species of small fish are put up under the name of sardines. Formerly, the United States imported most of her sardines, but of later years they have been obtained from the domestic market.

In the early days, canning was a haphazard business, but, as the business increased in importance, men were put to certain work and kept at it with the result that in a few years a corps of skilled laborers had been evolved. Canning equipment has been rapidly improved and extended until it now includes many extremely efficient automatic machines. The important positions are those of factory superintendent, foreman, clerk, and machinists. Most of the other work is done by foreigners. On the whole, labor is poorly paid. The Pacific coast pack of salmon in 1915 amounted to an equivalent of almost 400 million one-pound cans.

54. **Oysters** are found at a great many different places along the coast of the Eastern United States, where hundreds of fishing boats, called dredges, are busy gathering them. The oyster beds have been constantly overdredged and they must be cultivated in the future, if they are not to become exhausted. The Bureau of Fisheries has done much in the way of surveys along this line. The Chinese raise oysters in huge beds, preparing a place off the muddy bottoms for the young oyster to cling, by driving pieces of bamboo around the bed. This also prevents the tide from carrying the young oysters away.

The oyster industry of the United States belongs chiefly to the region of the Delaware and Chesapeake Bays. The oyster fisheries, as such, equals the value of the cod and mackerel fisheries of New England, and the industry is being rapidly developed by private cultivation of oysters.

During the time the fisherman is not busy gathering oysters he is engaged in collecting "brood" or young oysters for transplanting in the privately owned beds. It is said that in a single year an oyster will produce more than a million young ones. Most of them, of course, are destroyed in one way or another before they can grow up.

When oysters are to be gathered, men scoop them up from the bottom. This is called dredging. After being gathered, the fishermen sort them, usually into three or four different grades.

Great quantities are canned, but the fresh oyster trade grows more and more important each year. The inland cities have standing orders, and iced shipment is made daily from the beds. The express companies re-ice the oysters when necessary and they usually reach the consumer in excellent condition.

55. Other Uses of Fish.—While the chief use of fish is and always will be for food, yet they yield valuable by-products. One of the most valuable by-products is fertilizer. It was an Indian, Squanto, who taught the colonists how to fertilize their corn by putting a herring in each hill, and this method of growing corn in early times greatly augmented the meager yield. Now, only the skin, bones and viscera are used for fertilizer. Glue and isinglass are also made from fish. Codliver oil is noted for its medicinal properties. Fish oils have special uses. Whale oil, called "sperm oil," has, until recently, had no substitutes. Whales are not fish but are usually considered under that heading.

56. Work of the United States Bureau of Fisheries.—Both the States and the National Government have created fish commissions, whose duty it is to protect and increase the fish supply. In the salmon regions, millions of salmon are propagated artificially to take the place of those removed before they have a chance to spawn. If this were not practiced on a large scale, the salmon industry would soon disappear. It is remarkable that after the salmon start on their long inland journey from salt water up fresh water streams they cease to eat, and, finally arriving at the spawning bed, they spawn and die. No salmon spawns more than once and always dies shortly thereafter.

Disease of fish and oysters have received careful study and much has been done toward improvement, especially in the hatcheries.

In China nearly one-tenth of the population derive their living from fisheries. Hundreds of thousands of men crowd the coasts, fishing in every manner of craft, and by every conceivable method. Fish are marketed alive in almost every city.

It is said that an acre of water will produce more food than an acre of land and the increase of population in time will make necessary the utilization of water food supplies to the fullest extent.

MINING

57. So important are minerals to mankind that the stages of his development are based upon the utilization of metals. Thus we have the stone age, bronze age and iron age. Mining is the practice of extracting ore, metals, coal or gems from the earth. In each kind of mine there is a number of divisions of labor.

58. Coal.—In a coal mine, a **mining engineer** lays out a map of the mine. Under his direction test holes are drilled and the depth, angle, thickness and nature of the coal determined. After the mine is in operation, each chamber cut into the coal is laid off by the mining engineer before being made. Upon his reports the company base all mining operations. He sees that the machinery is of the right kind and properly installed, and he plans and directs the drilling, blasting, hoisting, drainage, ventilation, lighting and all provisions for the safety of the miners. The field of the mining engineer along research lines, in search of new mining methods, and new sources of supply is rich with possibilities. The mine is under the supervision of a **mine superintendent** who is placed in charge by the company. He supervises the work both on top and underneath the ground. A **mining boss** is employed to look after underground workings. He advises all the underground workers in the performance of their duties, in line with instructions received by him from the superintendent. Generally speaking, each mine is supplied with a **fire boss** who examines and reports the condition and amount of gas that accumulates. He is expected to see that a means is provided to carry fresh air into all working places.

Fig. 61.—Modern mine tipple.

The man who has charge of the power plant is the **engineer.** He is responsible for the operation of the ventilating, lighting, pumping, and power systems. He sees that the shaft cages are giving service and that all power machinery above ground is in order. A stationary engineer remains at all times ready to hoist or lower the cages upon signals from below.

Underground, the coal is mined either by pick mining or by machine mining.

Formerly **pick men** did all the work, undercutting the coal by hand, and loading it into cars. Now most coal is mined by machinery. A machine operated by a **machine runner** undercuts the coal to a distance of from 4 to 7 feet. Following, come mine workers who shoot or blast down the coal and load it into cars. A man may load from 6 to 8 tons per day in the average mine. The pay for the mining and loading of coal is divided in a certain ratio between the man who does the undermining and the man who shoots down the coal and loads it. Thus each ton of coal in machine mining is gotten out through the combined efforts of two mine workers. In some mines, special men are employed to shoot down the coal.

Fig. 62.—Under-cutting machine preparing for a blast.

Each car into which the coal is loaded holds on an average 3,000 pounds. These small cars are moved about either by electric locomotives or by mule power. Usually both are used, the filled cars being drawn from the face of the coal and replaced by empties with the aid of mules in charge of **drivers.** The train of cars thus collected is pulled to the shaft by the locomotive. The **motorman** of this electric train must be a mechanic, acquainted with electrical machinery.

Fig. 63.—Electric engine and cars in mine.

Trip riders have charge of the cars and act in a similar capacity as brakemen on a railroad train.

Water haulers dispose of water which collects in the rooms. They generally work at night so that when the miner goes to work the mine is dry.

Tracklayers are required to repair tracks and keep them well up with the face of the coal so that cars are in easy reach of the loaders at all times.

Timbermen are required in most mines to bolster up the walls and ceiling.

The **bottom cage man** has charge of loading the cars of coal on the cage and signals the stationary engineer above ground to hoist the cage.

Above ground, there are the dumpers, trimmers, blacksmiths, mine carpenters, couplers and greasers. Their wages vary, being small in most cases.

Anthracite or hard coal cannot be mined as above explained. It is so hard that a pick cannot be used on it. Usually the veins of anthracite coal slant upward and the coal is blasted from the vein in large chunks. It slides down the natural chute made along the bottom of the vein to the main track where it is loaded into cars. From here it is taken to the breakers where it is crushed into small pieces suitable for burning.

In some places, as in Eastern Kansas, coal is taken from the surface of the earth, only a thin layer of soil having to be scraped away. In many places tunnels are made in the side of the hill bearing coal strata and no shaft is required. The various mines present different problems in engineering depending upon location and kind of coal.

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Fig. 64.—Stripping coal in Illinois.

Formerly mining was the most wearisome, painful and dangerous of life's tasks. In olden times criminals, slaves, and vagabonds were compelled to work in the mines where they usually lasted only a few years. Mine rules and regulations together with improved machinery have changed all this, but even now the miner has enough danger with which to contend. The coal miner, especially, runs daily risks. He may be caught by falling roofs, an

inrush of water, a falling cage, a broken rope, or poison gas. A premature explosion of blasting powder or an explosion of gas may kill him outright. If gas explodes and the flames do not kill the miner, the heavy gases left, called fire damp, soon asphyxiate him. Also, the dampness, sudden changes in temperature and continual dust causes much pneumonia and tuberculosis. The most deadly foe of all is gas, but State and Federal appointed mine inspectors rigidly examine the ventilating systems from time to time, shutting down any mines not meeting all requirements in this respect. Many insurance companies will not insure miners, considering the risk too great.

While the miner receives good wages, his living conditions, as a rule, are not desirable, his surroundings unpleasant and his life unattractive. Also, while wages are good, there is usually considerable time off, the average mine operating little more than 200 days per year. The average period of the miner's earning ability is short as compared with other occupations. His chances for advancement are few. He usually starts in as a helper and, if a good worker, soon becomes a miner proper. He may become a boss, but that is exceptional. He might become a coal salesman or dealer but that is a long step from the mine. He is more likely to remain in his particular niche.

During the period from 1889 to 1909, the coal miner increased his individual output from 471 tons to 691 tons a year, as the result of more efficient machines and methods. According to the 1914 report of the Bureau of Statistics, the number of workers and tons produced were as follows:

	No. of workers	Tons of coal
Anthracite	179,679	90,683,991
Bituminous	583,506	422,137,415
Total	763,185	512,821,406

Coal is necessary today for furnishing a large proportion of our power and heat. Practically all other mining is dependent upon coal, either as fuel for machinery or in reducing ores.

59. Iron.—The 1915 output of iron in the United States amounted to 55,493,100 tons, valued at $101,288,984 and employed 187,000 men at the mines. During the 20-year period, 1889 to 1909, the number of iron miners increased 50 per cent, the capitalization 300

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Fig. 65.—Steam shovel at work in Minnesota mine.

per cent, and the output 400 per cent. The output per miner increased from 385 to 995 tons. This tells the story of increased efficiency, better engineering and equipment. Iron has been vastly more valuable to mankind than all the gold, silver, and diamonds ever mined. Iron ore ranges from a dirty yellow color, through brown, and red to black. Sometimes iron ore can only be gotten by sinking deep shafts, while in places it lies near the surface and can be mined without going underground.

The American supremacy in iron is largely due to the open-pit mines of the Lake Superior region. The iron region of this district extends in a line running across Northern Michigan, Wisconsin and Minnesota.

The Birmingham, Alabama area has a large deposit of similar ore and is second in importance in the United States.

The first extensive iron mining was begun with a pick and shovel both at the surface and in shaft mining. Soon mechanical experiments were made, and in open-pit mines the stripping or removing of the surface material was shortly being carried on with steam shovels. Owing to the rapidity of stripping with a steam shovel, much ore that formerly had to be worked by underground methods can now be surface mined.

Formerly underground mining was very wasteful, much ore being left as pillars to support the roof, and only the best ore being removed. Underground mining is more efficient than formerly, but it is still more wasteful of materials than surface or open-pit mining. Open-pit mining was so much more convenient, cheap and efficient than underground mining that the latter had to undergo considerable changes. Even with more efficient methods of mining, the open-pit mining has many advantages. It allows a much greater tonnage of iron per man. It requires few skilled men, as nearly all of the work can be done by laborers. The open-pit mine may vary its output almost at will or it may shut down without serious loss while the underground mine can do neither.

The men employed in an iron mine have duties similar to the work in a coal mine, so they will not be discussed here. The men are classified as miners, timbermen, shift bosses, loaders, pocketmen, ditchmen, trackmen, motormen, brakemen, trammers, skip-tenders, pumpmen, and pipemen.

In open-pit mining, the engineer makes special maps showing top and bottom of ore layers, location of the area to be mined, approach for the tracks, track system, drainage system, stripping dumps, and mechanical equipment. The stripping and dumping of the surface material is an enormous task and requires much work of laying temporary tracks and filling and dumping cars. To keep the huge steam shovels going steadily and the material removed is a huge problem. This requires a good pit crew and a well-organized dump gang, supervised by an efficient mine boss. The investment in a single mine for stripping alone may be millions of dollars and the surface may be removed to the depth of one thousand feet or more.

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Fig. 66.—An open-pit iron mine.

In stripping, an idea of the supplies used by a single stripping shovel may be gained by the following: An average shovel on a normal job in ten hours consumes three tons of coal, five gallons of lubricants and six thousand gallons of water. In the ore proper, a single shovel loads on an average of 75,000 to 100,000 tons of ore per month. In this work, the mining crew consists of runners, cranemen, firemen, pitmen and rockmen. Steel ore-cars holding on an average of 100,000 pounds are used to transport the ore from the mine. The market value of ore is based chiefly upon the iron content, and the nature of the impurities in the ore. The ore is usually sold at the furnaces at which place the problem of mining may be said to end.

For a careful treatment of iron mining see "Iron Mining in Minnesota," by C. E. Van Bareveld, University of Minnesota.

Mining Gold

60. The Prospector.—Before a mine is thought about, before valuable metals or ores are known to exist in a region, a prospector covers the

ground. The old-time prospector had but little technical knowledge and roamed around in search of sudden wealth in the form of a vein of precious metal. His discoveries were largely accidental and he as often passed by the ore without suspecting its presence. Accidental discovery played a more important part in early mining operations than did the prospector. The discovery of gold in California was accidental, and the man who first discovered gold in Australia was punished, for the people believed that he had melted down a gold watch and had not discovered anything.

The professional prospector must know how to prepare a camp, he must pack supplies on his back, he must be a good woodsman, and mountaineer, he must cook and mend and doctor, he must know how, when, and where to camp, he must have the courage and constitution to work or travel in all kinds of weather, he must have patience and endurance, perseverance, and faith, he must have some knowledge of surveying and plotting, and he cannot know too much of mineralogy and geology. The prospector is a pioneer in the mining industry.

In the United States, early prospectors searched chiefly for gold. In some places prospecting could be done only in summer, in others only in winter, and in a few places it could be carried on all the year around. The early prospector became a miner as soon as he discovered ore. He had no capital and usually could not hope to gain much except by selling his claim or by finding an unusually rich vein. His mining method was the simple process of washing, or panning the ore-bearing deposits.

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Fig. 67.—Gold miners' camp. Man panning gold.

61. Washing.—Washing is the simplest form of gold mining. The gravel is shoveled into a pan. The pan is held by the miner at a slight angle and given a rotary motion. The particles of gold, being heaviest, gradually collect in the bottom of the pan, and the lighter materials are washed over the edge by running water. During the opening of the great gold fields, this form of mining was practiced almost entirely and while very crude, wasteful, tiresome and unhealthy, yielded many wonderful fortunes.

In some of the early gold mines, there was more silver than gold, but this was not known at the time, because the test for gold was simple and easily made, while the best for silver was more difficult. In washing ore for gold, often the silver lost was worth more than the gold obtained.

62. The Mining Engineer.—The mining engineer is important in metal mines as well as coal mines. His work follows that of the prospector. He determines the probable area and extent of the deposit and makes borings to determine depth and quality. Based on the reports obtained from the chemist on samples, he determines the area of mineral deposits that may be worked profitably, and the condition affecting the cost of opening, developing, and working the mine. He must, to some extent, be a civil engineer as there are bridges, shafts, miles of track and dumps to be constructed. He must be a graduate from a school of mines or have equivalent experience. Usually a graduate serves an apprenticeship. Reliability is a first asset to a mining engineer and good men are always in demand at high salaries. The mining engineer formerly had little to do in connection with metal mining. When gold was taken by the simple placer method of washing, an engineer was not needed.

63. Sluicing was the first mechanical method of mining gold and the mechanical skill needed in this connection was small. The problems of supplying running water and constructing sluice boxes were the main ones. A sluice box consisted of a long narrow inclined chute, across which projections, called riffles, were placed. Quicksilver was placed in the sluice box at the riffles and, as the gold-bearing material was shoveled into the top of the chute and carried down by running water, the gold was absorbed by the quicksilver. When the quicksilver became saturated with gold, it was collected, and the gold separated from the quicksilver.

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Fig. 68.—A big sluice.

64. Hydraulicking.—In hydraulicking, the problems of the engineer were more complex. The chief problem was to obtain a sufficient flow of water under a high pressure. This method of surface mining is carried on by working down a bank of gold-bearing gravel by a stream of water at a high pressure. The washed-down gravel is carried by water through sluices, which catch the gold in quicksilver as explained under sluicing.

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Fig. 69.—Hydraulic mining.

65. Dredging.—The work of dredging requires a much higher degree of engineering skill, not only in laying out the drift for dredging, but in securing the right kind of machinery and manipulating it properly. The fact that the dredge is the only appliance used in placer mining which transports its sluices and continually provides new room for its tailings renders it attractive as a mining method. Dredges can be used in river beds, where shallow drifts occur. The dredging machinery lifts the gravel and gold by means of buckets working on a continuous chain which passes around a dredging ladder. The dredging ladder may extend to a depth of sixty feet or more, which allows quite deep drifts of gravel to be dredged. The dredged material is dumped into sluices and the gold separated. A stacker, consisting of long chains carrying stops and working over an inclined chute, carries the refuse, called tailings, to the rear of the dredge, where it is deposited again in the river bed. Tin is often found in connection with gold, and, in New York for example, both tin and gold dredges are in operation.

66. The improved methods of mining and more thorough extraction of metals is due largely to the advancement made by the chemist in devising methods for separating metals from the ore cheaply and economically. The assaying chemist is needed from the time ore is discovered until the workings are exhausted.

Samples taken from different places must be analyzed to determine the value and extent of the mine. The work of the chemist does not stop here. After the mine is in operation, every train load

of ore has samples removed for analysis. Ores from different parts of a mine are carefully watched and the new directions of work are determined in part by the grade of ore found. In the iron mines a number of samples of ore are taken from different cars in each ore train. By the time the train reaches its destination a telegram is waiting giving the exact ore content of the train. This knowledge is necessary as a basis for selling the ore and to determine the grade of iron to make from the ore. The same principles are applicable to the other ores. The assaying chemist is usually a college graduate. Pay is excellent, employment steady, and reliable men are in demand.

67. The workers previously mentioned do not work directly in the mine, in fact the assaying chemist may never so much as see the mine. The better positions associated more directly with the mine are mine inspector, superintendents, mine bosses, stationary engineers, and blacksmiths.

A mine inspector is needed in metal mines, but he does not have so much gas to contend with as in coal mines. Mine inspectors cover all mining districts and investigate the mines in detail with reference to the conditions and safety of operations carried on. All accidents must be reported to the inspector at once and are investigated either by him or his deputies. A mine inspector as well as a fire boss must have a license showing that he is qualified for the work. He is either a Federal or State employee.

The blacksmith at the mines is a sort of machinist and has many and varied tasks. He has tools to sharpen and repair, machine parts to make, and, in fact, all kinds of metal work. He must work long hours, at hard physical toil. The remuneration is not large, but is much above the ordinary labor around the mine. The blacksmith should have at least a high school education and work as an apprentice to qualify for the trade.

The mine is run on three shifts, and the shift bosses report all men missing or ill and any other thing of importance. They tally loads of ore and waste rock on a printed sheet.

Watchmen make regular rounds. Messengers carry orders where the telephone does not reach. Also, they carry water and gather up dull tools and replace them with sharp ones. The miners, drill men and drifters are the men who chop out the passages and ore. These men fill dangerous positions and work hard. Their hours are short and the pay good for unskilled laborers.

68. Formerly most gold and silver was obtained from near the surface by the methods mentioned, but more and more is now coming from deep mines. The gold mined in the United States for the year 1915 was valued at $101,035,700. The price of gold is fixed by law at $20.67 per fine ounce. The principal gold producing states rank as follows: California, Colorado, Alaska, Nevada and South Dakota, and these five states together furnish nearly 81 per cent of the total output of the United States.

69. The production of silver during the year 1915 was valued at almost thirty-eight million dollars. The price of silver has steadily decreased, varying from $1.34 per fine ounce in 1865 to 52 cents in 1915. The principal silver producing states in 1915, in order of output, were Nevada, Utah, Idaho, Colorado and Arizona. These five states produced more than 90 per cent of the total for the United States.

All mines may be divided into two classes: surface mines or placers, and deep or lode mines. The placers are those in which the material is recovered from ore-bearing materials by washing, sluicing, hydraulicking, or dredging. The deep mines produce metals from underground workings. Many deep mines are worked for a certain metal and others metals obtained as a by-product. There were about 1,500 placer mines and 3,500 deep mines producing gold and silver in 1915. Placer mines have been decreasing in number since 1911, the rich surface deposits having become less paying. Deep mining has been increasing continually. It is in deep mining that the engineer has his greatest problems. Engineering feats of underground mining are remarkable. The network of drifts, or tunnels, stopes or rooms, and machines make the present-day underground mine a complex thing compared to ancient mines. Some of our mines extend to a depth of almost a mile, having horizontal drifts or workings every hundred feet or so. Engineers have driven copper mines to this great depth.

70. Through the combined production of these wonderful underground mines and the numerous surface mines, the United States has become a leading copper producing nation. Our production in 1915 was valued at more than twice the value of all gold mined during the same year. Arizona, Montana, Michigan and Utah produce over 80 per cent of this output. Other metals are usually found in copper ores. For example, the mine production of silver from domestic copper ores in 1915 was almost nineteen million fine ounces. Copper

is found in its pure state in many instances and is easily separated from other materials.

Most metal and non-metal mines are operated by the various workmen previously described. Other metals, not previously discussed, large amounts of which are mined in the United States are zinc, lead, aluminum and tin. Other very important ones mined in smaller amounts are antimony, quicksilver and tungsten.

The importance of the mining industries and the great field of mine workers is shown by the value of the product. The value of all minerals produced in the United States in 1915 was $961,572,662.

71. Zinc.—Spelter is the trade name for metallic zinc and the principal domestic production of the ore is obtained from Missouri, Wisconsin, Colorado, and New Jersey. Zinc is usually found in connection with lead, the ore being called lead-zinc ore. The production of gold from lead and lead-zinc ore in 1915 amounted to over two million dollars. The production of zinc in the United States in 1915 was over one hundred and thirteen million dollars, more than the value of the gold mined that year.

72. Lead.—The production of refined lead in the United States in 1915 was valued at more than forty-seven million dollars, a value greater than all the silver mined the same year. Most lead ores contain silver. Sometimes the silver is taken out and sometimes it is left in. When taken out, the lead is made softer thereby and is said to be "desilverized."

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Fig. 70.—Shaft house, smelter and tailing pile, zinc and lead mines, Joplin, Mo.

73. Aluminum.—The consumption of aluminum in the United States in 1915 was valued at almost eighteen million dollars. Aluminum is largely produced from an ore called "bauxite," the great bulk of which comes from Arkansas. Bauxite is used for other things besides making aluminum, as for fire brick and abrasives. Much experimental work is now going on in the endeavor to obtain aluminum cheaply from various ores.

74. Tin.—In 1915 tin ore valued at $78,846 was reported for the United States. The tin imported for the same year was valued at

almost $39,000,000. Tin is often found in connection with other metals.

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Fig. 71.—General view of copper mining and smelting plant.

75. Copper is an especially valuable metal, and the United States alone produced in 1913 almost one and one-half billion pounds. It is obtained from ores which vary in many respects, but they usually carry the pure copper in minute flakes disseminated throughout their structure. The ore is mined both from surface veins and from underground deposits. The methods engaged resemble those used in mining iron and, as far as operations in the mines are concerned, the two may be considered together. The prospector, assayer, mining engineer mine boss, and inspectors, are all essential to the copper mine and their duties have been previously described.

76. Petroleum, or crude oil, like stone, is not mined but is obtained through an extraction process. Deep wells are sunk and the oil either flows or is pumped into huge tanks. From these storage tanks the petroleum is taken to the refineries. This oil is often transferred through large pipe lines which stretch for miles across the country to the refineries. By the process of refining, products are obtained, numbering into the hundreds. Among the more common ones are paraffine, vaseline, kerosene, gasoline, benzine, phenol, napthalene, and toluene.

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Fig. 72.—Oil field in Kansas.

Drilling for oil and its storage, transportation and refining, require the services of many men, and each branch of the work is a

specialized trade. The importance of these trades is indicated by the fact that the United States produced in 1915 more than three and one-half billion barrels of crude oil. The chief producing states are California, Oklahoma, Illinois, Texas, Louisiana, West Virginia, Ohio, and Pennsylvania.

77. Stone.—The principal building stones are limestone, granite, marble, sandstone and slate. Pennsylvania ranks first as a stone producing state. Next in order of value of the product comes Vermont, New York, Ohio, California, Indiana, and Massachusetts.

Limestone is obtained from almost every state. In 1915 Pennsylvania ranked first, Ohio second, Indiana third, and New York fourth, in the value of stone produced. The total value of the limestone produced for that year was over 35 million dollars, and more than 11 per cent of this total was sold as building stone.

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Fig. 73.—A granite quarry in New Hampshire.

Granite is obtained chiefly in Vermont, Massachusetts, California, Wisconsin, North Carolina, New Hampshire, and Maine. The total value of the granite sold in 1915 was almost two and one-half million dollars. About 20 per cent of this was used for building stone.

The value of the sandstone produced in 1915 amounted to over six million dollars. Ohio, Pennsylvania, and New York, in the order named, were the leading producers.

(Copyrighted by Keystone View Co.)

Fig. 74.—Drilling preparatory to splitting stone at the quarry.

The value of the marble quarried in 1915 was almost seven million dollars. The important producing states are Vermont, Georgia, Colorado, and Alabama. Stone is quarried chiefly by the aid of machinery. The blocks of stone are sawed, cut, or drilled and blasted out of the quarry bed, hoisted to cars and transported to the market.

78. Before going into any phase of the mining industry, the student should have work in geology and should know what phases of mining appeal to him. It is hard and usually impossible to obtain the better positions in mining without an adequate education. With a good mining education, the field for advancement is almost unlimited.

MANUFACTURING AND MECHANICAL PURSUITS

79. The people engaged in agriculture, lumbering, fishing, and mining are concerned with what is termed raw materials. Some of the material is practically ready for consumption in its raw state, but the greater part of it is put through processes, so that when it finally reaches the consumer it bears little or no resemblance to the raw material of which it is made.

While agriculture as an occupation ranks first in point of numbers engaged and value of the product, manufacturing and mechanical industries are second in importance. Millions of dollars are invested in factories and equipment and the combined output of all industry is beyond the comprehension of the average person. There is in connection with the many industries a somewhat natural grouping according to the nature of the materials and the use to which they are put. This grouping is given below, arranged according to the number of people working in each case:

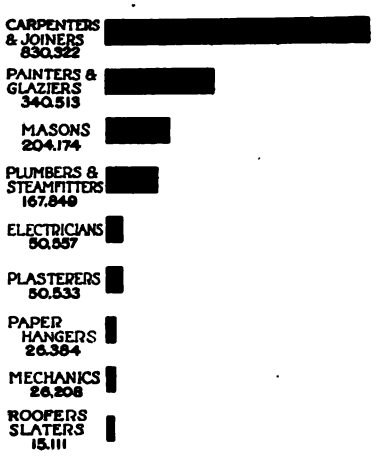
Building trades	1,661,094
Lumber and furniture industries	667,064
Metal working trades	1,984,487
Food and kindred industries	493,130
Textile and clothing trades	1,978,439
Paper, printing and bookbinding	359,153
Clay, glass and stone	333,554
Miscellaneous	3,181,960
Total	10,658,881

The Building Trades

80. There are probably more than one and three-quarter million workers in the building trades. These trades are the ones with which

we are most familiar, because wherever people live, with very few exceptions, the handiwork of these artisans is present. A community may not have machinists, boilermakers or structural iron workers in its midst, but there will usually be people present who have had experience in the building groups. We find scattered over the country approximately the number of workers indicated by Chart V.

CHART V.—SHOWING DISTRIBUTION OF WORKERS IN THE BUILDING TRADES.



To this group should also be added builders and building contractors to the number of about one hundred and sixty thousand, and architects and draftsmen to the number of nearly sixty thousand.

81. **The Architect.**—The term, architect, calls to the minds of most people the man who draws plans for the ordinary residence, but this is only a small part of his work. The architect is an engineer, and in the designing of buildings, his work, along with engineering, calls for ability to plan artistic structures such as homes, schools, churches, and huge sky scrapers.

Therefore, the architect's daily work requires that he be thoroughly acquainted with wood, brick, stone, concrete, steel and other building materials. He should know the various elements of good construction because one week his work may consist of designing a dwelling and next week in planning a factory, or he may have various types of work in the office at the same time. Added to this, he should know the cost of material and labor, and understand both building and working conditions.

His work requires that he shall have a thorough knowledge of the technical aspects of the profession. Moreover, he should have had training in art and applied design necessary to enable him to add those touches which give a building the distinctive elements that make it beautiful.

It is almost necessary that he shall have graduated from high-school, and, for large and technical work, a special course in architecture is essential. Usually, after completing such training, he first serves as a draftsman in some architect's office, at from $12 to $20 per week. Advancement depends upon his ability. He may advance to the position of chief draftsman in the office and be paid as high

as $75 or $100 per week. After a period of practical experience, he will probably be prepared to establish an office of his own. The practicing architect is paid a commission on the cost of the building which he has designed or the construction of which he is supervising. The work of the architect, if he is thoroughly prepared, and located in a thriving community, should be remunerative. If he designs and prepares plans and specifications, his commission is usually 3 per cent, but, if he supervises the construction of a building for which he has prepared plans and specifications, his fee ranges from 5 per cent to 6 per cent of the total cost. It affords a splendid career for the young man who feels that he is especially adapted for this line of work. If he is lacking in engineering and artistic ability, he may assume that it is not the field of work for him.

82. **The Building Contractor.**—There are many kinds of contracting, but, as treated here, the discussion will be confined to the kind of contracting that one is likely to think of first, that is, building contracting. The greater part of all construction work carried on today is by means of contract work. One contractor agrees to build steel ships, another to construct huge office buildings, another to conconstruct railroad lines, and so on, including a large and varied number of industrial activities.

Fig. 75.—Excavating for a large building.

Contracting is the means by which the average individual, company or corporation proceeds to secure a certain result in the form of a given product, whether it be a dwelling house, skyscraper, bridge or ocean liner. The nature of contracting work is such, that the contractor must have at his command such an organization of production, materials and men as will enable him to produce a given kind of work with a high degree of efficiency.

The contractor is not necessarily an architect or designer, though among the smaller building contractors he often supplies the plans from which the work is constructed. The tendency in modern industry is toward specialization so that at present few contractors supply the plans and specifications from which they work. A man wishing to have a dwelling constructed comes to the contractor with his plans and specifications, or with certain ideas more or less definite

concerning what he wants done. The contractor is then in a position to submit a bid, stating the amount for which he will be able to complete the job, including the construction work only or construction and material. Success in contracting depends, in a large measure, upon the manner of preparing the bid or estimate. To intelligently prepare an estimate, the bidder must know his materials and their cost, how to purchase them to the best advantage, the best methods of construction, and finally how to successfully organize and handle his men. The small contractor who does not have many jobs going at one time usually follows the progress of the work very closely, acting very much in the capacity of a foreman. The large contractor carries on his work by means of superintendents, job foremen and others, to whom he delegates the authority of supervision.

The contractor, since he is his own boss, has no definite hours of labor but will probably be found working long hours at times and again in slack seasons he may not be very busy. He has no stated wage, his earnings depending entirely upon how successfully he has bid upon a contract and how efficiently he has carried it through to completion. At the present time, competition in the contracting field covering practically all lines is keen, and to make a success of the work requires executive ability and knowledge of efficient methods. Many stories are told of early contractors in the building of transcontinental railroads and other huge enterprises receiving fortunes, but, in the main, those days are past. The individual contractor who is thoroughly keen and alert and knows every phase and angle of his business, if there is new work available, may expect to do reasonably well financially.

Fig. 76.—Showing mass of rods necessary in reinforced concrete in building construction.

To successfully meet competition as a contractor, it is almost necessary that the individual should have worked up through the trade. In so doing he acquires an insight into the work and the viewpoint of the man on the job which is a factor that will enable him to handle his men successfully. There is no definite apprenticeship to be served, other than through the ranks of a journeyman in some of the allied trades. His schooling should cover, in addition to the practical work of the trade, such subjects as estimating, drawing, strength

of materials, and a knowledge of the building laws and regulations. He may succeed with nothing more than an eighth grade education, but a high school training along technical lines would fit him for greater possibilities in this field.

The logical steps of progress in the development of a contracting business is to work from a small business requiring very little capital, gradually growing and developing and widening the field, until able to handle large jobs. It would be the line of advancement found in any business growing from a small concern with little capital to a large corporation with millions of dollars back of it. The lives of many successful contractors have followed closely this sequence of progression through from the ranks of journeyman to the position of president or general manager of a large contracting corporation.

83. The Carpenter.—The daily work of the carpenter has a very definite relation to the work of most all other building tradesmen. This is made apparent in following through the construction of a building. For example, a client visits an architect's office, desiring to have a residence built, and tells him that he wants a frame building of a given number of rooms, shows him a tentative floor plan, specifies certain conveniences and about the amount of money to be put into it. The architect proceeds to draw up the plans and submits them to the client for approval. Then a contractor is secured to carry out the work. The contractor has the basement excavated and the mason puts in the footings and foundation, and later the fireplace and chimney. The carpenter erects the frame and roof, puts in the partitions and takes care of all the interior work such as floors, stairwork, trim, hanging of doors and windows, and in some cases the making of built-in cabinets and other special features. The electrician wires the house for electric lights, or it may be piped for gas before the walls are

Fig. 77.—Carpenters at work on frame structure.

Fig. 78.—Much carpenter work is required in a large building like this.

plastered, and the plumbing lines are likewise installed in the walls. Then, following the lathing of the walls, the plasterer finishes the walls, the carpenter completes the interior woodwork, the tinner or sheet metal man puts on the gutters and spouts, and then the structure is ready for finishing outside and inside. Thus, we see that the work of the carpenter is most intimately connected with the work of all the other building trades. One is very much dependent on the other, and in a measure we can thus account for the delay often encountered in building construction.

Specialization has not in a large measure affected the carpenter. There are only two general groups, the men doing the framing which is more or less rough work, and those doing the interior finishing which is the finest work of the trade.

The dangers in the trade are not great. It is true some of the work is done on scaffolding, but not at great heights. Ladders are used to a considerable extent, but the work throughout is not what might be classified as dangerous.

Fig. 79.—A large frame building in process of construction.

The work of the carpenter is healthy and invigorating, in the majority of cases being largely outdoors. The work is done with hand woodworking tools almost entirely, equipment with which all boys are more or less familiar. The rough, heavy work frequently encountered requires a good physique, but this is usually done by the less skilled men. The highly skilled men do the finer kinds of work, much of which is inside finishing, and it is quite customary for them to have a helper, if heavier work falls to them. The work affords a considerable variety from day to day so it is not monotonous.

The eight hour working day for the carpenter is now very general throughout the country. In many places they may be working longer hours, but, if that is the case, overtime is usually received. The wages vary from $3 a day for unskilled rough work, to $6, and in some cases even more for the highly skilled man.

The men capable of commanding the high wage lose very little time during the year, their services are in demand and their work is most often indoors, and is not affected by inclement weather. The carpenters with limited skill do not usually find employment the year around, losing probably from thirty to sixty days.

Fig. 80.—Building forms for concrete construction.

The trade is of such a nature that men work at it for a long period of time. It has been stated that the active career in the trade will average from 25 to 40 years.

There are at least three ways in which a boy or young man may start in the trade. The oldest method, and the channel through which a large number come, is the apprenticeship; the second is by working as a helper in the case of the older man, and gradually acquiring the skill; and the third is by means of training in a vocational school.

Upon taking up the work of an apprentice, the boy is usually from 16 to 18 years old and should have had at least a common school education. He agrees to serve a learning period of from three to four years at a specified wage for each year, while the employer agrees to teach him the entire trade. The wage is variable, but ranges from $6 to $8 per week for the first year, $8 to $10 for the second, and $10 to $12 for the third year.

The apprentice, during his learning period, must be keenly alert to everything around him, because his experience will be gained in this manner. He should at all times endeavor to keep on good terms with all the men on the job, because it is through them that he will receive most help. In many respects, the apprenticeship system is wasteful of time actually spent on work of value to the boy, but nevertheless he is gradually taking on the habits of the journeyman and is acquiring something that can be obtained only by actual contact with the daily work.

Many older men enter the trade through the helper stage. That is, they start as unskilled labor on a carpentry job and are subsequently given a piece of work that requires increased skill. They move from job to job and gradually become skilled men. This method is not the best and should be recommended only for certain individuals.

An increasing number of boys are coming into carpentry through the vocational school. The schools are developing real work under conditions that are encountered in the trade, and, since they are organized from the standpoint of instruction, the boy gets, in the shortest possible time, the fundamental elements of his trade. It does lack the rubbing of shoulders with a mixed lot of workers and there is something lost by it, something, however, which will be quickly

acquired once the boy is on the job. The vocational school supplements the real trade work with work in architectural drawing, mathematics related to the trade, and other work that will help the boy to make a success. All vocational schools are not yet on the high plane they should be, and boys should not expect to leave the school and immediately enter into journeyman standing.

By whatever channel boys or young men enter the trade of carpentry, if they are going to advance in the occupation, they must supplement the practical experience gained on the job by evening school work, correspondence study, reading of trade journals, and by contact with the most skillful men of their trade.

The trade itself is of such a character that it holds at present many opportunities for the ambitious young man. The first logical step after a thorough mastery of the trade is a promotion to a foremanship where he has the directing of men and the planning of work. This type of experience lays a splendid foundation for the next step, contracting. As a carpenter contractor, his field is somewhat narrow, but it opens the way to the larger opportunities afforded in general contracting. In contracting of all kinds, he is "his own boss."

Architecture also affords a splendid outlet from carpentry for the boy who has marked ability in drawing and design, and who is able to make preparation for it.

These are some of the things that make carpentry, as a trade, desirable for a young man to take up as his life work.

84. **The Mason and Bricklayer.**—The work of the mason and bricklayer is necessary in the building trades group. The mason sets stone in building construction and the bricklayer lays brick in foundations, walls and chimneys for frame structures, and, in the case of brick buildings, erects the outer walls in their entirety.

The work is almost entirely out of doors and therefore reasonably healthful. The workman needs to be robust and able to stand a day's work which involves continuous activity. Bricklayers, especially, in working on a wall, find it necessary to keep a very definite pace, laying brick after brick rapidly without loss of motion. The work may seem monotonous, but a spirit of competition is injected and the bricklayer views with considerable pride his day's work. The

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Fig. 81.—Bricklayers working on a high wall.

trade is one which requires the utmost of a man eight hours a day and the older men are gradually weeded out as they are unable to keep the pace. The stooping posture, which is a bending of the body in a straight line from the hips, and which is necessary in picking up the brick and mortar, is at first very trying to the worker, but he soon becomes accustomed to it. The skillful handling of a brick, the trowel and the mortar is an art, and comes only through long practice. The work of the bricklayer or mason is not considered very dangerous. He very frequently does work on tall buildings, but present day laws provide that all scaffolds shall have railings on them, and also overhead covering. These safeguards have, to a large degree, eliminated accidents.

The mason and bricklayer work the same number of hours per day that the carpenter does, in fact all of the building trades workmen enjoy the eight hour working day. The wages vary from $4 a day to $7.50 and $8 for the skilled journeyman. He does not actually work as many days in the year as the carpenter, but owing to the higher wages, the average yearly income of the two is about the same. In many parts of the country it is the custom of the younger bricklayers and masons to move very frequently, especially in the winter time, going to the warmer sections. By this means they put in a longer working year.

The boy starts his apprenticeship at the same age and under much the same conditions as in carpentry. Another way in which the boy may enter this trade is through the vocational school. The vast majority of boys, however, enter through the medium of apprenticeship. This is usually a three to four year learning period. During the first year, his work is very largely that of laborer or helper. He is not trusted to build any part of the structure but does such work as the mixing of the mortar, helps with the setting of scaffolding, and is general handy man to the journeyman. Finally, after a year or so, the bricklaying apprentice is permitted to work on laying in brick on the inner face of plain walls. Gradually, he is allowed to try the finer kinds of work, such as arches, pilasters, and fronts of buildings. When he is able to do this work skillfully, he will rank as a journeyman. The apprentice stone mason works up in the same manner.

These apprentices receive approximately the same wage during the learning period as the apprenticed carpenter. Again, is found, as in the previous trade, an increasing number of recruits from the vocational schools. There are several exceptionally well equipped schools in the country training boys to practically fulfill requirements

of journeyman standing. Also, there are many more that can not be rated so highly and consequently their graduates should expect to enter the trade as apprentices with advanced standing. Again, the boys that graduate from these schools to the trade bring much in the nature of drawing, mathematics and related sciences that the regularly apprenticed boy never secures on the job. Wherever the worker gets his training—on the job or in the school—he should be constantly supplementing it with study that will keep him abreast of developments in his work.

As in carpentry, the most obvious outlet for the mason or bricklayer is the contracting business. In a few instances, it leads to a foremanship and, if the worker has a technical inclination, to contracting.

85. Plumbing.—Plumbing is considered one of the comparatively modern trades. Fifty to seventy-five years ago, plumbing was very little used. Today, in all types of buildings except the simplest structures, plumbing of some kind is to be found. This marked change has come about as a result of education pertaining to sanitation, heating and ventilation. In most states and cities, laws and ordinances require plumbing systems to meet a definite standard. This is a decided recognition by the state that the plumber's work is a necessity in every community, and, as education along hygienic and sanitary lines grows, so will the trade of the plumber grow.

Fig. 82.—The plumber calking a joint in soil pipe.

Plumbing is done in two installments. Before the walls are finished the drains, water lines, gas lines, ventilating stacks and all plumbing which is concealed is placed. This is called "roughing in." The roughing-in work is usually inspected before the building proceeds. After the rooms are finished, the fixtures, such as sinks, bath tubs, wash bowls, and gas stoves, are installed. After all fixtures are in, the plumber connects the water and gas supply and tests the entire system for leaks and other defects, leaving the job completed ready for use. The immediate tasks of the plumber in-

clude the measuring, cutting, threading and calking of both cast and wrought iron pipe and also the cutting and bending of lead pipe and the wiping of lead joints. The plumber uses hand tools almost entirely. Only in the largest shops, do we find machines for the cutting and threading of large work. Much of the work demands skill and accuracy, but not to the extent that some of the machine trades do. The most desirable part of the plumber's work is the installing of new plumbing, but much of his time will also be spent in repair work. This includes opening plugged-up drains, taking care of frozen water pipes and sewage systems, and repairing bathroom and kitchen fixtures.

This is a healthful occupation and there are no special physical requirements for plumbers. Occasionally, there is heavy lifting to be done and it is often rather disagreeable making repairs, but on the other hand, the work is varied and interesting and many jobs demand a great deal of ingenuity, so that the plumber must be constantly on the alert to meet successfully new situations.

Plumbers have an eight-hour day and the wages vary, averaging from sixty to seventy-five cents an hour. The busy season is during the spring and summer, at which time most building and repair work is done. During the winter months, in the colder sections of the country, there is much emergency repair work to be done. The capable plumber may expect to have rather permanent employment.

The trade is recruited almost entirely by the apprenticeship method. In general, the work of the apprentice during the first and second years is that of the handy man, helping on jobs, and thus learning the tools and their uses and also the materials. During the latter part of his second year, he will probably be allowed to calk soil pipe and do a little lead work. The third year, he still works with a journeyman, doing the simpler jobs and acting as general assistant to the skilled man. The fourth year, if he has proved his ability, he will be sent out on jobs by himself. The usual term of apprenticeship is five years. The last year, they rank as junior journeymen. The wages of the apprentice will run from about ten cents an hour for the first year to approximately thirty-five cents for the fourth year. More and more each year are students of technical and trade schools entering the trade from the school shops. These students have the advantage of a general fund of knowledge concerning the technical features of the work, such as the science of plumbing, drainage, action of bacteria in sewage, drawing, mathematics and general building construction. Ordinarily, these students are given

advanced apprentice standing and in some cases are made journeymen without serving as apprentices.

Plumbing offers, as one of the opportunities for advancement, the possibility of becoming a contractor. This does not require a large outlay of capital, and one who is skillful in his trade, understands the jobs, and can foresee their demands, may expect to be reasonably successful. If a plumber is a keen student of sanitation and other allied subjects, and is able and willing to take additional training, an unusually interesting and promising field is open to him in sanitary engineering.

86. Steamfitting.—In many respects, the work of the plumber and the steamfitter are quite similar, and, in the smaller towns and cities, very little distinction is made between them. In the larger communities, each has a distinct organization and the work is quite definitely divided. In the main, the work of the steamfitter consists of the installation of steam and hot water heating plants, the running of all lines of pipe for refrigeration plants and piping connected with steam heating and power plants where lead is not used.

Fig. 83.—Showing work of steamfitters.

Practically all members of this trade have entered as apprentices. The wages and hours for the journeyman steamfitter are about the same as for the journeyman plumber. The opportunities for advancement are not quite as good as in the plumbing trade. Contracting, for example, can not be so easily entered into, because the jobs are bigger and require more capital to handle.

87. Plastering.—Plaster is the common wall covering used in almost all buildings. The work consists of spreading plaster, with a mixture of hair in it, upon the walls and ceilings of rooms. The workman must use enough pressure when spreading the plaster to force it through the openings between the laths. The first coat is only roughly smoothed and is followed by a second coat much like the first, except that it does not contain hair. If a third coat is used, which consists of lime and plaster of Paris, it is put on very thin and the surface quickly and smoothly finished. If only two coats are used, the second coat becomes the finishing coat. A patent or prepared plaster is used

Fig. 84.

almost entirely in present building construction.

Plastering is considered a healthful occupation, as the work is not heavy and does not involve any strains or contact with poisonous materials. Much of the work is done from a scaffold and it is necessary that the worker reach over his head, especially for ceilings, but he soon becomes accustomed to this.

The apprentice starts at a good wage, from fifteen to twenty-five cents an hour. The journeyman plasterer receives from fifty to eighty cents an hour. The demand for the work of the plasterer is determined by the amount of building in progress, the building season being, of course, the busy season.

In smaller places, the general contractor hires the plasterers, but, in larger cities, there is an opportunity to branch out as a plastering contractor.

88. Electrical Wiring.—In this day, which we may term the electrical age, there is a large and growing demand for people trained to do electrical work. For our purpose, we may think of this occupation as being divided into three parts or classes; electrical apparatus work, inside wiring, and outside wiring.

Fig. 85.—Fishing wire.

The people working on electrical apparatus are concerned with the manufacture and repair of electrical equipment, such as generators, motors, meters, telephones, switchboards, testing and signal apparatus. This work is so varied, and covers such a wide range, that it is impossible to take it up here in its many branches. Outside wiring means the running of wires for the transmission of

power, street lighting and communicating lines. Inside work, the one with which we are probably most familiar, is concerned with the installation of wiring systems for lighting, heating, power communication and signals. To do this work as it should be done requires an understanding of the theory of electricity, methods of installing electric wires and conduits, and a working knowledge of the electrical and building codes. Not a great deal of manipulative skill is necessary. The tools most used are pliers, connectors, the screw driver, brace and bits, and the soldering torch.

The work of the inside wireman is not dangerous and is among the most healthful of the building trades. The outside wireman, who comes in contact with high voltage transmission lines, needs at all times to observe the greatest caution as the slightest slip or mistake may mean injury or instant death.

The hours are not the same in the different kinds of work. The men doing house wiring, which is classified in the building trades group, usually work eight hours. Those doing the other kinds of work spend nine hours a day at it. The wages range from thirty to sixty cents, the tendency being to pay the higher wage to the men doing house wiring. The demand for such labor is steady.

The boy who has a natural bent for mechanical devices and electrical appliances should consider this trade seriously. Very few boys come in as apprentices—usually they begin as helpers. Several of the large electrical companies conduct private schools in their plants where they have a thorough system of apprenticeship training for young workers. These schools are, for the most part, excellent and afford a good means of becoming an electrical engineer or other high grade workman along electrical lines. A great many also come in from the vocational schools. An electrician needs some practical mathematics and physics, especially along the lines of applied electricity and magnetism, while mechanical and architectural drawing will be of help to him. All these things are given him

Fig. 86.—Wiring a house. Note flooring removed to place wires.

in the vocational school course. A two or three-year course, where work of a practical nature is given, will prepare a boy for usual journeyman standing. A course of this kind gives him both the practice and theory of the trade, and what he lacks in the experience of working on large contracts will soon be gained on the job.

The electrician may run a supply and fixture store along with the practice of his trade, thereby making more money and affording added satisfaction to himself. Besides, he may do contracting. To the young man thoroughly grounded in the elements of electricity and with the necessary experience, the field of electrical engineering offers alluring inducements. Preparation for such work requires more study than many other trades, but electricity will be used more and more as time goes on and will open a new and uncrowded field well worth striving to enter.

89. The Painter and Decorator.—The work of a painter and decorator is coming to be recognized as a highly skilled and essential trade. A few years ago it was not considered necessary to know anything about the materials used or the surfaces to be treated, but of late years the value of a thorough knowledge both of processes and materials has come to be recognized. The interior decorator, especially, needs to have ability in drawing and a knowledge of pigments, and color mixing.

Fig. 87.—Painters on outside work.

Paint is applied nowadays for two reasons: First, it preserves the wood, keeping the sun, wind and rain from affecting it; and second, it adds to the appearance of the building, which is a factor that is growing in appreciation. The work of the painter is developing and will be given greater importance as people come to realize that frequent painting will reduce cost of upkeep and repair.

The painter and decorator's work is quite varied, but house painting is the most important phase of the work. Some of the things that the painter does, other than the laying-on of coats of oil paint, varnish, water color, stain or calcimine, are, the preparation of the wood, plaster, and metal

surfaces, removal of old finishes, mixing of paints and stains, rubbing down varnish and enamel coats, and, in some cases, graining, gold leaf work, lettering and stenciling.

90. House painters with whom we are most familiar are divided into two general classes: brush hands, whose success is rated by the amount of surface that they can cover in a day; and the painters who understand the mixing of paints and stains, and are experienced in interior finishing. The first thing the painter does on beginning a job is to prepare the surface for the paint. In the case of new interior work, this means sandpapering and dusting. In old interior work, it means using a burner, scraper, or solvent to remove the original finish and then rubbing with sandpaper. A priming is then applied, being brushed well into the surface and allowed to dry thoroughly, after which all nail holes and cracks are puttied and one or two more coats of the final color are given.

91. In interior finishing, dyes of the desired color mixed with water, oil, or spirits are usually first applied to the surface. The pores of the surface to be finished are then treated with a liquid or paste filler and rubbed to remove any particles that may remain on the surface. A number of coats of varnish are then applied, each being rubbed until the desired finish is obtained. The greater part of this work is carried out in the building being constructed or repaired.

92. Calcimining requires that all walls or surface shall be thoroughly cleaned, and cracks and holes filled. The walls are then given a coat of thin glue, called sizing, which causes the calcimine to hold well to the wall. Fresco painting, which is a high grade of work, is done while the walls are still damp. Gold lettering, sign painting and graining are types of high class work done by expert painters.

This occupation involves no undue strains or lifting. In house painting, swinging scaffolds are used, but, with reasonable care, this involves no danger. Many of the materials with which the painter works are poisonous and care must be exercised in their use, such as cleanliness and using devices to keep down dust. If precautions are taken, a healthy individual should feel no bad effects from following the trade.

93. **Paper hanging** is closely allied with painting, a large percentage of painters being able to hang paper. The trade includes the hanging of all paper or other fabrics used for covering walls, and the preparation of walls to receive the same.

As a first step in papering, old paper must be scraped off, cracks and depressions filled up and the walls made smooth. If only one thickness of old paper is on the wall, and if it is tightly glued, the new paper may be put over it. Then a thin liquid glue, known as sizing, is usually applied and allowed to dry. The paper is laid on a pasting table, face side down, and cut into strips a little longer than the surface to which it is to be applied. Paste, of cheap wheat flour and alum, is applied to a strip which is then folded so it can be readily handled. In hanging, a dry brush is used to press the paper smooth. Each strip is so placed as to project over the space allowed for the border.

The apprentice, or helper, when he begins to learn the trade, receives a very small wage. Competent painters or paperhangers average $4.00 for a day of eight hours.

The vocational schools must give the worker the hygiene of his occupation, that he may know how to safeguard himself. Perhaps in the near future, they will realize the value of giving a course that will include color harmony, drawing and designing, so the tradesman will bring to his work a trained artistic sense that will enable him to rise from a painter or paperhanger to an interior decorator. Interior decorating is modern as applied to homes and very popular and almost unlimited as to possibilities. The painter often establishes his own shop and begins contracting after serving for a time as foreman for a gang of men.

94. Structural and Ornamental Iron Work.—There are two rather distinct divisions under this heading. The first group is called the ornamental iron workers, and the second the structural steel workers. There is a growing demand for workers in this field, for, in many fields, metal is replacing wood and other materials. Ornamental iron workers manufacture and erect grill work, elevator enclosures, balcony railings, inside and outside stairs, fences and all forms of ornamental work of a light character. Very few castings are used in this work, cold rolled steel being used principally where sharp corners and clear lines are required. These workers, in most cases, work from detailed drawings. When the drawing reaches the shop, the iron or metal of the proper size and kind is selected, cut to proper lengths, and the rivet holes, joints and other dimensions laid out. After this laying-out has been done, it goes to the workers on the machines who drill or punch the various sized holes. Curved and bent work is sent to the blacksmith who shapes it. After the work

has been punched, sawed, filed, drilled and shaped, it goes to the mechanic who assembles it. The assembling is done from detailed

Fig. 88.—Structural steel work in factory building construction.

drawings which are in the hands of the mechanic. It then goes to the man who paints and finishes it.

In structural steel work, all work is carried on from detailed drawings that are sent to the foreman of the structural department. The **layers-out** take the drawings, have the proper metal selected, and then proceed to lay out for lengths and rivet holes. After the laying-out is done, it is sent to the punchers, cutting-off machines or drill presses, where the pieces are cut to size and shape, holes are drilled or punched and the work prepared for the **assemblers.** The assembling is done by means of rivets and bolts. After the assembling of certain parts of this work, they are then sent to the location, where the structure is to be erected. Men called **erectors** now take up the work and place different parts of the structure in their proper position, these parts again being held by means of rivets and bolts. The erector is working out of doors, and, in cold climates, is of course exposed to all kinds of climatic conditions. Furthermore, he is exposed to the danger of falling, as his work necessarily involves working in many cases at a considerable heighth. The workers in the shop handle heavy materials and work in close

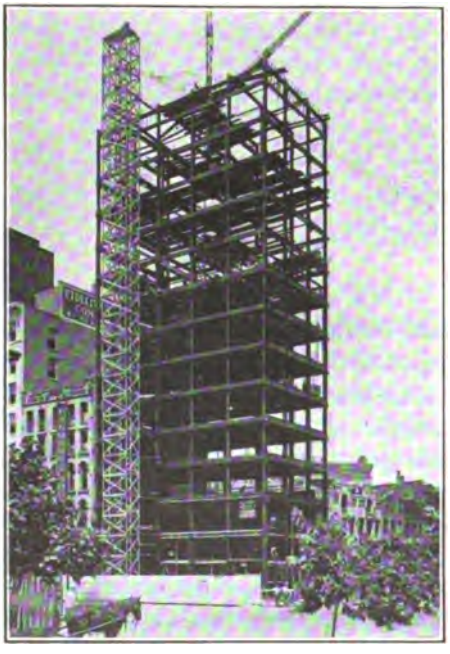

Fig. 89.—Structural steel in building construction.

proximity to large machines, and consequently there is some danger. Factory laws, however, have minimized machine danger to a large extent by requiring safety devices on all machines.

Structural workers work from 48 to 54 hours per week. Their busy season is the usual building season. The wages vary considerably, ranging all the way from $3.00 to $6.00 per day. Entrance to the trade is made both by the apprentice system and through the ranks of helpers. To become a thoroughly competent worker requires from three to four years. To advance in this work, the assembler and erector especially should have a working knowledge of mathematics, strength of materials, riveting joints, and mechanical or architectural drawing.

For the ornamental worker, a knowledge of free hand drawing and designing is a most decided asset. An eighth-grade graduate, if he is keen, alert and ambitious, will probably succeed, but he will find that he must take night-school work in order to advance very far. Again, the high-school graduate, with some time spent in technical work, is very well prepared to succeed in this field. The line of advancement is to foremanship, directing a small group of men, from the foremanship to a superintendency, involving the directing of large numbers of workers, and possibly to a general managership.

95. Saw Milling.—In addition to the great mills employed in the manufacture of lumber on a large scale, there are in towns and cities over the country many smaller saw mills. These are called "custom mills," as most of their work consists in getting out special bills of stock for houses, barns or other buildings. They may be either portable or stationary mills. Many of them purchase logs or timber from the farmers or land owners in the locality and cut them into lumber and frame stuff. Each has a log and lumber yard. In the latter, the material is piled or placed "on stick."

A custom mill gives employment to a sawyer, off-bearer, edger, slab or cut-off saw man, engineer, and sticker. In addition, others may be employed in the yards to skid logs, to pile slab wood and to assist in sticking. Also, in the mill, helpers may be needed to assist the sawyer, the off-bearer and edger, or to do general work.

The sawyer operates the carriage that carries the log to the saw. He must know how to get the most and best lumber out of a log in plain and quarter sawing. Most of the lumber in a custom mill is plain sawed. (See Arts. 25 and 26, Sec. 2.) He keeps the large saws in shape by setting and filing, and, in rare cases, may even "hammer" the saws. He may look after measuring the logs and lumber, and usually acts as foreman of the mill. His work requires more ability

and experience than any other work about the mill, and he draws the largest hour wage.

The off-bearer carries away the boards as soon as they drop from the saw. If they need edging, he places them by the edger's table; if they are to be cut to length, he delivers them to the cut-off man; if they are finished boards, he places them on a car to be taken from the mill. He usually receives good wages, as his work is heavy.

The edger is generally a man of experience. His main work is to remove bark or bad edges from boards by ripping on a small circular saw. His pay is about the same as that received by the off-bearer.

The slab or cut-off man must be strong, as he handles heavy pieces, but his work requires little skill or experience. The engineer may have "to fire" as well as to look after the engine. His work requires a knowledge of boiler and engine operation and he usually draws good wages.

The helpers, stickers and yard men receive fair wages.

A custom mill may not run steady; in fact, quite a little time is lost in such mills each year. There is not much chance for advancement in these mills, as the sawyer holds the best job and may remain with the mill for years. He may own the mill or operate it for some individual or company.

96. Planing Mill.—Planing mills are very necessary plants, located in cities and the larger towns. These mills are usually equipped with planers, jointers, band saws, circular ripping saws, cut-off saws and other power machines for surfacing, jointing and making dimension stock. The material may be surfaced or rough when received, and is generally seasoned, but many mills have dry kilns. Considerable stock of all kinds is usually carried and stored in sheds. Rough material that has not been seasoned is piled in the open.

The principal work of the planing mill is to furnish material for houses, business buildings, barns, and factory structures, including decking, weatherboarding, shingles, laths, flooring, and doors. Formerly, the frame stuff for buildings was provided by the custom sawmill for most jobs, but such stock, especially in cities, is now procured at the planing mill. Window and door frames are made in the planing mill, as are also special cabinets and cases. In fact, the foreman or manager of the mill usually "figures" the bills of material for carpenters and contractors and when an order is received turns it over to the men in the mill to get out the stock. Along with lumber, and frames, most mills sell other building materials, such as lime, hair, cement, window cord and weights, glass, and nails.

Men engaged in a planing mill must be experienced in operating

the different machines, unless the mill has sufficient business to require men for each kind of special work, or to operate certain machines. The men must be able to use hand woodworking tools, must know how to read blueprints and execute problems of construction. Their work is interesting, is more or less skilled, except in the case of stock handlers, and the wages are usually good. There is little opportunity for advancement in a planing mill except from helpers to machine operators, general workmen, or foremen, but experience in such a mill opens the way to other wood-working establishments engaged in furniture or cabinet making, where wages or piece work methods may offer inducements.

97. Furniture and Cabinet Making.—Furniture and cabinet making covers a wide range of work. Under this heading comes the construction of such articles as household furniture, kitchen cabinets, pianos, and caskets. During the past few years there has been as complete a change in this industry as in the metal working industry. The old cabinet maker of a few decades ago was almost entirely a hand worker in wood. Today, growing out of the large demand for a cheaper grade of cabinet production, machine work is the predominating feature. As we have found in various lines of the metal industry that specialization is the striking feature, so is this true of the furniture industry. Some plants specialize to the extent of turning out only chairs, others again will manufacture other restricted and specialized lines of output. In this trade, as we have already indicated, there are two distinct classes of work; hand work, which is used only on the very high grades of construction, and machine work, where hand work is eliminated, aside from the necessary assembling.

Fig. 90.—View in large furniture factory.

The general stages or steps followed by the workers in the furniture factory can be roughly grouped into certain classes.

All work in the furniture factory is carried on from full sized drawings or "rods" as they are called in this particular trade. The men employed as designers are usually high class men with a good understanding and appreciation of the styles of furniture and the

artistic elements which go to make up beautiful designs. Furthermore, they must thoroughly understand the construction, as this is a vital element in products of this chararter. The materials that enter into cabinet or furniture production are usually purchased in the rough, dried in the kiln, then cut to necessary size, after which the milling operations are performed. In a general way, this is followed by assembling, gluing and finishing which completes the manufacturing process. All work of this kind in each department is directed by a foreman, who routes the work and is held responsible for the output of his department. The machine operators perform a large number of operations. One man, for example, operates the cut-off saw, that is, he does nothing more than cut material to a specified length. Another operator rips material to a certain width. The material then goes to the planing operator who feeds the material between the rolls, and to the knives that remove the rough surface and reduce the stock to a given thickness. The stock is joined by another operator who passes the stock on edge over revolving knives which give a true edge, at right angles to the face. After the stock is surfaced on four sides, it is usually laid out by means of templets or forms which indicate irregular shapes and the places where the mortises and tenons will come. If the stock is to be cut to an irregular shape, the band saw operator takes it. A special man operates tenoning and mortising machines. If it is necessary to use wide widths of boards, the stock is joined carefully and glued by special men who are proficient in this work.

Fig. 91.—Showing section of kitchen cabinet factory.

After the many parts of certain pieces of cabinet work or pieces of furniture are machined, they are taken to the assemblers. Assembling in some cases, requires fitting, and involves the use of bench and hand tools. Glue and screws are used as the means of holding various parts of the construction together. This means that the assembler must be proficient in the use of the various kinds of clamps.

Much of the work that is done today in cabinet shops and furniture factories is made out of veneered stock. Many plants have their own veneer department where this stock is glued up in three or five

Fig. 92.—Illustrating the spray method of applying finish.

sections, termed by the trade three or five-ply stock, using for the center or the core a rougher, poorer grade of material, and putting on the outer face a choicer stock, as mahogany or walnut. This veneered stock is used largely for panel work. After the work has been assembled, it is necessary that all excess glue be removed from the joints and some scraping and finishing done before the stain or finishing material is applied. The work in the finishing room is quite distinct from that of the cabinet maker and is discussed more fully under the work of the painter and finisher. Much of the work in the modern furniture factory may be classified as semi-skilled, as machines have replaced part of the old and better type of hand labor. A large number of the operators in a modern plant are simply machine workers.

The modern factory has good ventilating systems, and the extensive use of safe guards on all kinds of machines has rendered work reasonably safe. There is no heavy lifting or excessive strain involved.

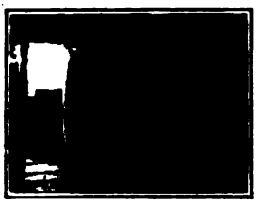

Fig. 93.—A fuming room.

The hours range from eight to ten per day, and the wages run all the way from 20 to 50 or 60 cents per hour. For the skilled workers, the demand for labor is reasonably permanent.

The industry is recruited almost entirely from the ranks of unskilled workers. It takes but a short time to make a skilled machine operator of the person of average intelligence. The skilled work of the assemblers, and the workers on the better type of furniture requires a definite learning period of from three to four years. Many workers skilled in other woodworking trades enter this work and progress very rapidly. Young men who have had preliminary training in woodwork and cabinet making in technical schools adjust themselves to this work very quickly. The trade as a life work offers good opportunities, if the individual will prepare for it. He may start as a machine tender, work up to assembler, from that to a foreman, and, if he has the training that will enable him to design furniture, he may get a position that will reward him exceedingly well. The boy with the high-school education which includes practical woodworking and a good course in the elements of applied design has the foundation for successful work in this field.

THE AUTOMOBILE INDUSTRY

98. The entire group of metal trades, while it has always occupied a very important place in our industrial life, has assumed a far greater importance in the past few years. Our progress seems to be moving toward the perfection of mechanical devices to lessen human labor and efforts. As we look about, we see old methods, considered especially good a short time ago in the modern industrial plant, giving way to an entirely new procedure. Our modes of travel are constantly changing, our methods of farming are in the process of change, and wherever we turn, whether it is in industries concerned with the manufacture of agricultural implements or in the automobile or other industries, we find a decided movement toward improving mechanical production.

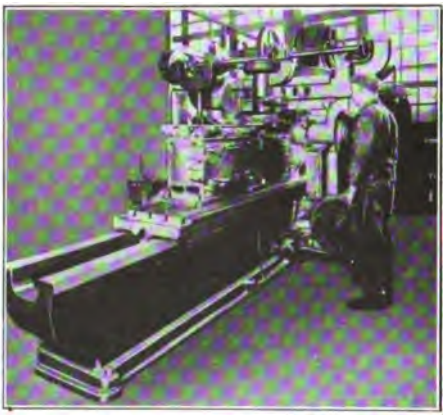

Fig. 94.—A large planer smoothing off the bottom of a six-cylinder casting.

It is interesting in this respect to study briefly the automobile industry as a modern type which shows a marked growth and improvement. In the course of a period of only 20 years from 1899, when there were about 2,200 workers or wage earners engaged in the production of automobiles and parts, the number of workers has rapidly increased until today there are approximately 500,000 engaged.

Fig. 95.—Drilling aluminum crank cases. Note the size of this multiple drill.

The value of production in this period has increased from approximately $4,750,000 to $1,367,470,000. In considering the automobile industry as a whole, a most interesting fact is brought to our notice by a study of the chart on pages 10 and 11.

It is a type of industry which shows the interdependence of one industry upon another. It shows how vitally dependent this particular industry is upon a large group of others. Another fact that is growing out of the development of the automobile industry is that the high standards of workmanship required in the manufacturing process involved in the construction of cars is being

Fig. 96.—Lapping-in motor.

secured by the employment of a comparatively small number of skilled workers in this industry. This is due primarily to the fact that the automobile industry has adopted new methods of production. It has specialized its factory processes to a degree found in perhaps no other line of manufacturing. It has brought to play what is termed, scientific management. As may be noted from Table 5, which covers the workmen in a typical automobile factory, the work naturally falls into four subdivisions.

Table 5

List of Operatives in a Typical Automobile Factory

(From section of the report of the Educational Survey of Cleveland, Ohio, dealing with "The Metal Trades.")

Wage workers	Per cent
Productive—54 per cent	
Drill press operators	9.6
Lathe hands	7.4
Milling machine operators	5.4
Hand screw machine operators	4.0
Bench hands	3.6
Wood machine operators	3.1
Automatic screw machine operators	2.5
Bench molders	2.3
Machine molders	2.3
External grinders	1.8
Sheet metal machine operators	1.6
Core makers	1.6
Blacksmiths	1.1
Internal grinders	.9
Polishers	.9
Gisholt machine operators	.9
Tool makers	.8
Cleaners	.8
Turret screw machine operators	.7
Gear cutters	.5
Tinners	.5
Disc grinders	.3
Heat treaters	.3
Floor molders	.3
Electric welders	.1
Semi-automatic machine operators	.1
Acetylene welders	.1
Furnace tenders	.1
Gear shaper operators	.1
Tumblers	.1
Sand blasters	.1
Flask makers	.1
Assembling—17 per cent	
Body assemblers	3.1
Motor assemblers	2.6
Chassis assemblers	2.6
Transmission assemblers	2.2
Steering gear assemblers	1.7
Fender fitters	.9
Axle assemblers	.8
Clutch assemblers	.8
Final finishers	.8
Body fitters	.7
Electricians	.5
Wheelmen	.3
Finishing—12 per cent	
Back hangers	1.6
Cushion makers	1.6
Sewers and pasters (women)	1.3
Gear painters	.9
Top makers	.9
Varnish rubbers	.9
Sanders	.8
Rough stuff rubbers	.7
Back makers	.7
Enamelers	.5
Sprayers	.5
Color varnishers	.5
Finish varnishers	.5
Stripers	.3
Cutters	.1
Hardwood finishers	.1
Rough stuff men	.1
Inspection—6 per cent	
Road testers	2.6
Parts inspectors	1.8
Motor testers	1.6
Miscellaneous—11 per cent	
Laborers	10.0
Millwrights	.9
Carpenters	.1

The **productive** occupations comprise and employ about 54 per cent of the total working force. It is among this group that we find specialization and the subdivision of labor have been carried out to a very high degree. The technical knowledge and skill formerly demanded of the workers is now the work of the engineering and designing departments. In the productive list of occupations will be

mentioned is probably not so apparent in other industries as in the automobile trades.

The second group of workers which includes about 17 per cent of the total working force is called the **assembling** group. Here also specialization is carried out to a high degree. Every worker assembles a given part of a given section of a car. There are motor assemblers, steering gear assemblers, body assemblers, and so on, each separate group engaged in putting together a single mechanical unit. While this work may be highly specialized, still it requires a high degree of skill. The work, organized to the degree indicated, very shortly develops experts in each of these fields.

Fig. 97.—Dynomometer test of motor. Completed chassis.

The third large group is called the **finishing** occupations and includes such work as painting, cushion back making and jobs of a similar nature.

The fourth group is called the **inspecting** or **testing** class. Many plants that manufacture cars buy parts of their machines from other companies which specialize in their production. This requires a group of inspectors who test these various parts as they come from the manufacturers. The plant that manufactures all of its own products requires a smaller force of testers and inspectors. All parts of a machine are tried out very carefully and adjusted before leaving the factory. It is the desire of the manufacturer to detect all defects in construction or operation before the car is placed on the market.

The wages paid in the automobile industries are somewhat hard to indicate. As the work ranges all the way from highly skilled to a comparatively low skilled work, it is almost impossible to indicate

found practically all the workers of the majority of trades represented in any other metal working industry. Specialization which has been

Fig. 98.—Upper end of final assembly room.

the definite scale, but it is approximately 20 cents to 75 cents per hour. In many automobile plants the workers are paid upon a piece-work system. The hours of work vary from eight to ten. Most of the trades, if we may term them such, since they are of low skill or semi-skill rank, require comparatively short periods to learn. In this respect, about nine-tenths of them do not require over six months to learn.

Fig. 99.—An experimental shop.

Since the automobile industry is found almost entirely in large plants, there are numerous possibilities for advancement to foremanship and heads of departments, but, like all industries, the ambitious person must make the necessary preparation by taking up night school work or correspondence study covering such subjects as shop mathematics, drawing, strength of materials and other subjects related to the work in which he is engaged. The outlook for the automobile industry is very bright and, if they are prepared for it, people engaged in this field of work may expect to have an exceedingly good future.

Metal Working Trades

99. Designing and Machine Drafting.—There is a decided difference between the designer and the draftsman. The designer is the mechanical engineer who works out the plans and general features of construction.

The draftsman is the worker who takes up the suggestions and general plans of the designer and works out the details. In many cases the draftsman has very little responsibility thrust upon him other than to reproduce certain drawings, while often the work of the designer demands the most accurate mathematical calculations of strains and stresses, strength of materials, contraction of metals and like technical knowledge. With the advent of mechanical progress in every field of human endeavor at the present time, both the designer and the draftsman occupy most important places in the occupational world. We hear it said over and over that we are in a mechanical age, and every indication leads us to believe that future development is going to be most extensive. The work of the designer involves planning and thinking out how different mechanical devices, of one kind or another, may be built to meet the demands of some given situation. Today it may be the making of a particular type of ammunition, involving a special machine to do it. Tomorrow, it may be a special kind of an engine for aeroplane service; and so on we might enumerate a vast field of mechanical problems that he is called upon to solve. He must sit down at his drawing board or desk and work out the principal features, keeping constantly in mind the various elements of construction. It requires, on his part, a thorough knowledge of the science of mechanics, the mathematics necessary to compute the strength of different parts, and a broad general knowledge of the entire mechanical field. This usually requires years of practical experience and education, and also broad technical training.

The draftsman, as indicated previously, takes from the hands of the designer the general plan as worked out by him and prepares detailed drawings that will enable the different workmen to construct the machine or device planned. While this does demand considerable mechanical ability, it is not the ability of the broad character possessed by the designer. The designer may leave many little things or points to be developed and worked out by the draftsman, but the general plan is the effort of the designer. Many draftsmen do nothing other than make pencil drawings of these suggestions and from the pencil drawings in turn produce drawings from which blueprints or working drawings are made for the mechanic. The time spent by the designer at his work from day to day

is hard to put in terms of a given number of hours. He usually carries his work with him. He may put in from seven to eight hours in his office, but his work is of such a character that it is not very far removed from his thoughts for any long time. On the other hand, the draftsman's work ends in most cases when he leaves the drafting room. The designer's salary ranges from $1,500 or $2,000, to as much as $100,000 (in some extreme cases) per year. The majority of successful designers are men who have had a good general engineering or technical training in a college or university, supplemented by the practical experience in the shops. Draftsmen, on the other hand, start at a comparatively small monthly wage and may average, if quite successful, $150 to $200 per month. The draftsmen are drawn from the ranks of high school or technical schools and from men who have completed some college work. In some cases the draftsmen have advanced from the shop. Such men have been ambitious and have supplemented their shop training with correspondence or evening school work. In some few cases young men have served definite apprenticeships, but this has usually been in connection with the larger corporataions. For the ambitious draftsman who is willing to study and make the necessary preparation, the field of the designer is always open. It requires intensive study, either through correspondence or a period in a technical school, to prepare for this advancement.

100. The Pattern-Maker.—The pattern-maker is often termed the aristocrat of woodworkers. The character of the work which he is called upon to do is of such a nature that it requires a very high degree of skill and understanding of mechanical construction. The work of the pattern-maker is necessary in securing castings of any kind. The drawing as it comes from the designer or draftsman is placed in the hands of the foreman of the pattern shop who in turn takes it to one of the journeymen pattern-makers. The foreman may indicate some general feature concerning how the pattern is to be constructed and then place the responsibility of its being carried out upon the workman. The pattern-maker studies his drawing, noting carefully all the features required in the casting. He forms in his own mind a general conception of how this particular pattern will

Fig. 100.—Making wood patterns.

be placed in the sand by the molder so that it may be most efficiently withdrawn. Following this more or less general study, he reproduces on his work board a full sized section and plan, if necessary, of the drawing. From this he is able to see the exact features of the pattern, how it will be constructed and the material necessary for building it. He then proceeds with the getting out of his stock in rough dimensions, taking it to his bench, and laying it out accurately, following which it is shaped, either by machines or hand tools. The parts are assembled and finished by the use of sandpaper and, usually, two or three coats of varnish. The pattern-maker comes in contact with machine tools such as band saws, rip saws, jointers, lathes, and special machines. His bench tools are a combination of the carpenter's, cabinet-maker's and wood carver's tools. Much of his work can be done on machines, but still it requires a great deal of hand work, especially in producing odd-shaped patterns. His work is entirely with wood, if he is a wood pattern-maker, and very seldom is he called upon to use other materials. There are also metal pattern-makers who produce patterns made of different metals. The same principles hold true in connection with the production of metal patterns as with wood, except of course the difference in the processes involved in working different materials. To be successful in pattern-making requires that the pattern-maker shall be a skillful wood worker, able to read working drawings rapidly and accurately, familiar with the elements of the molder's trade, and also possessed of an intimate knowledge of the work of the machinist. If the pattern-maker knows something about the work of the molder, in many cases he can shorten the labor necessary in the foundry and also assist the machinist materially in many respects.

Fig. 101.—Making metal patterns.

The work of the pattern-maker is not dangerous, since practically all machine tools are now thoroughly guarded. We also find in many pattern shops ventilating and blower systems which carry off the dust. In some of the smaller shops, there still remains the dusty condition which is detrimental to the health of the workers. The work itself is light, clean,

and, in the main, is considered one of the most desirable of the occupations allied to the so-called machine trades.

The pattern-makers work on an average of between eight and nine hours a day. They receive for their work from $4.00 to $7.00 per day.

The trade is recruited almost entirely by the apprenticeship system. The term of learning is approximately four years in all parts of the country. The average boy entering the trade should have an eighth-grade education, in fact, it is almost necessary that this be the minimum education. The first year, the boy receives approximately $1.00 per day and is used largely as a helper in the shop. The second year, he receives about $1.25, and is given simple jobs in the shop. The third year, his wages will probably advance to $1.50 or $1.75, and he is then doing a very good grade of work. In his last year, he is usually paid $2.00 or more and is holding his own in many respects with the journeyman workers. A few boys come into the trade through trade and technical schools. In some cases, they are given advanced credit for the work done in these schools. Again, others come to the trade through other woodworking occupations, but usually the average woodworker has a difficult time in picking up the trade.

The usual opportunity is afforded every ambitious boy in this trade to progress to the position of foremanship and frequently pattern-makers go on to positions in the drafting room. This later advancement does not always mean greater wage, but does involve quite a change in the type of work. Opportunities are also open to the ambitious young man to advance from foremanship to other positions, such as assistant superintendent and superintendent of the plant. To progress very far in industrial organizations usually requires more than an eighth-grade education. The high-school boy who has had a technical training as a foundation is better prepared to successfully cope with the work of the pattern-maker, and is ready in part for future advancements. It is absolutely necessary for success in the trade that a boy have a knowledge of shop mathematics, machine drawing, knowledge of the materials used in pattern-making, and, as before indicated, an understanding of the trade.

101. Molding and Core-Making.—In the production of metal castings, the molder and core-maker hold most important places. After the pattern leaves the pattern shop, they are responsible for the placing of it in the sand, withdrawing it, and, in turn, pouring the molten metal into the mold, thus producing the rough casting. They not only make iron castings, but also brass, bronze, aluminum and

Fig. 102.—In a large foundry.

steel castings. The molder's problem is one of placing the pattern properly in molding sand, seeing that the sand is tamped to the proper firmness and so withdrawing the pattern that it leaves a clean-cut impression in the damp sand. Most frequently, the sand is held in boxes called flasks, which keep the sand from falling down; at other times the pattern is embedded in the floor of the foundry. After the pattern is withdrawn from the sand, the cores, which are baked sections of sand of the same size and shape as the cavity on the inside of the casting, are set in place, and the flask is closed. Usually there are two parts to each of these flasks, which are held together by means of pins. Following the closing of the flask, the molten metal is poured into the cavity through an opening provided for that purpose. After the casting is cool, it is removed from the flask and has the outer shape of the pattern and an inner cavity resembling the core used. It is now called a rough casting. The molder must be thoroughly familiar with the action of metal when poured into these cavities, know his sand, and make provision for the escape of certain gases. His work is heavy as there has as yet been few mechanical or labor-saving devices invented to help him. He stands and works in damp sand practically all day and must handle heavy flasks of sand.

The core-maker's work is somewhat distinct or different from that of the molder. He receives from the pattern shop supplementary parts of the pattern, called core boxes, which he uses, in connection with a specially prepared sand, to shape the cores. These cores are then baked, and, if they are made in sections, are pasted together. When needed by the molder, they are hard and substantial and are ready to be placed in cavities in the sand. Usually the core-maker's work is not as heavy as that of the molder in shops engaged in producing large work.

Both the molder and the core-maker receive good wages, ranging from $4.00 to $6.50 per day. They sometimes have considerable overtime, which increases this daily wage. Their average day is from eight to nine hours.

The trade is recruited almost entirely by the apprenticeship

system. The period of apprenticeship is approximately four years in all places. The boy starting at about seventeen years of age at near $1.00 per day, gradually receives increased pay until he is paid about $2.00 or $2.50 per day. There are few schools at the present time preparing boys for entrance into this work. In fact, most molders have only an eighth-grade education or less. There is a place in the trade for boys who have had the technical training that will give them an understanding of some of the elements of metallurgy and thus prepare them for a foremanship with the ability to handle and prepare different mixtures of metal. The usual line of advancement, as in other shop work, is to that of foreman and then from foreman to the possible position of superintendent. Also, there are possibilities for the workman to establish a foundry for himself and develop from the foundry a complete plant equipped to handle the various kinds of machine work, both new and repair.

102. The Machinist.—The work of the machinist has assumed a place of the utmost importance due to the advent of the automobile, and increased shipping facilities. On every hand we encounter mechanical devices for the decreasing of labor and the increasing of production. The machinist, in the minds of most people, and quite rightly too, is the one who finally prepares and assembles the many thousands of parts that frequently go to make up a machine and complete it for use in the world's work. In the past few years, the work of the machinist has changed to a considerable degree. Twenty-five or thirty years ago the machinist was a mechanic thoroughly familiar with practically all branches of the machine trade. He could operate most of the machines then existing. He was familiar with the many processes involved, and was in every respect an all-round mechanic in this field. At the present time, and apparently it is on the increase, specialization has brought about a change in this field of work. Increased production demands that a mechanic shall be a specialist and capable of turning out a certain product in the least amount of

Fig. 103.—A machine room. Note the drilling machine in the foreground.

time. We can readily see that, if a man does nothing but one particular operation day in and day out, he very shortly becomes proficient, consequently we find that no longer are there the all-round machinists, but in the vast majority of cases a machine specialist, who is able to secure the maximum machine production on his particular job. As we go into the automobile plant, the shipbuilding plant, or the general machine manufacturing industries, we note on every hand that this is one of the principal elements of the organization. A man running a lathe does nothing but turn a certain piece of metal to a given length and a given diameter, completing as many of them as possible each day. The next man's job may be something different, but still the same element prevails—specialization to the highest degree. In many shops, men who are capable of doing a number of things are found, but this is more especially true of repair shops. These men are similar to those we think of when we talk about the older type of machinist. They may be called upon to run a certain machine or do a special line of work one day, do bench work the next day, and possibly what is called assembling on another day. This calls for the all-round trained mechanic. In the tool rooms, where special tools, jigs, and fixtures are made, one will usually find all-round mechanics. Their particular work is to prepare certain devices that will enable the machine tender to turn out a greater product. These tool makers are high-class machinists who are called upon to exert, in many cases, a high degree of ingenuity in helping to solve certain problems related to increased production. In some lines of work, which involve the manufacture of small instruments of one kind or another, there are high-classed mechanics called instrument makers. Instrument makers are specialized to a certain

Fig. 104.—Gear cutting machines.

Fig. 105.—The screw cutting room in a large factory. Note the great number of machines, each doing the same kind of work.

degree, but not to the extent that is found in a factory that produces a staple product, by which is meant producing thousands of articles of a single model. The work of the machinist may be divided into three general classes: machine work, bench work, and assembling. The machine work may consist of working on a lathe, a planer, a milling machine, a grinder, shaper or various other machines. The tendency, as before indicated, is that the machine man will turn out simply one kind of product. The work of the bench hand involves hand work, such as special fitting, which includes chipping, filing and scraping, and requires, on the part of the worker, a high degree of skill. The assembler is the man who takes the various parts of the machine under construction and puts them together in the proper relation to each other. It is under his hand that the machine is carried through to completion and is put in shape for

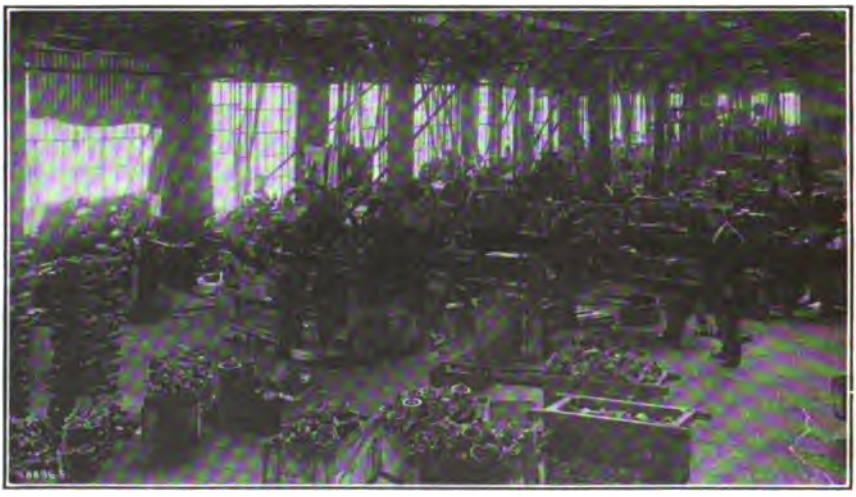

Fig. 106.—A large factory shop equipped to turn out various machine parts.

actual operation. The assembler or erector is usually a highly skilled man, and holds one of the most responsible positions in the machine shop. There is no great danger in the work of the machinist, if care is exercised in the use of the various machines. Machines in the modern factory are in most cases carefully guarded, thus minimizing the danger to the worker. There is not a great deal of dust, and very little danger from flying pieces or particles; neither is there heavy lifting, since nearly all modern shops have found it profitable to employ hoists and cranes for this purpose. The work, as all work in connection with machines which must be lubricated, is somewhat greasy, but not to any harmful extent.

The average length of the working day of the machinist varies from eight to nine hours, with plenty of opportunity to work overtime.

The wages of the machinist have been on the increase for the last three or four years, and a good machinist averages from $4.00 to $7.00 per day. In the case of machine work produced on the piece work basis, which is a form of payment that has been gradually increasing, many workers make much in excess of the amount indicated. Large numbers of boys enter the trade through the apprenticeship system, which is a period of learning of about four years in length. Since the trade has become so highly specialized, it has also been recruited to a large extent by machine operators, who have been taught the operation of some simple machine in a short time. Again, graduates of trade schools and technical schools find their way into the machine shops. A well organized trade course, given in good vocational schools, brings a great deal to the boy that he does not secure in the average apprenticeship.

The wages of the boy, while learning, range from $1.00 to $2.50. Machinist's work, as a stepping stone to advancement in machine trades, offers splendid opportunities. The machinist who has had a good opportunity in the shop is much better prepared to assume the superintendency or managership of this kind of an industry than any other workers in the metal trades. The machinist's work gives him a broad view of the whole field, and, if he has been ambitious and has made the necessary preparations through night schools, correspondence school, or some other means, the opportunity is before him to work into some of the higher positions. Many young boys entering this trade will do so to much better advantage, if they are high school graduates, than if they had entered it with only a grade school education. The opportunities in this trade are very bright, and as we look ahead we can see on every hand future developments of mechanical devices needful to meet modern industrial demands. Our fields of transportation and communication, and, in fact, all phases of life are going to be affected by the introduction of more and more mechanical devices, thus requiring the services of the trained mechanic in this field.

103. Blacksmithing or Forging.—The term, blacksmith, usually calls to mind such a man as the Village Smith described by Longfellow, or in other words, the man who shoes horses, sets tires, and does the repair work on farm implements and other rough machines. Lately, the work has become highly specialized, and the modern garage, or machine shop, bears little resemblance to the old type of shop.

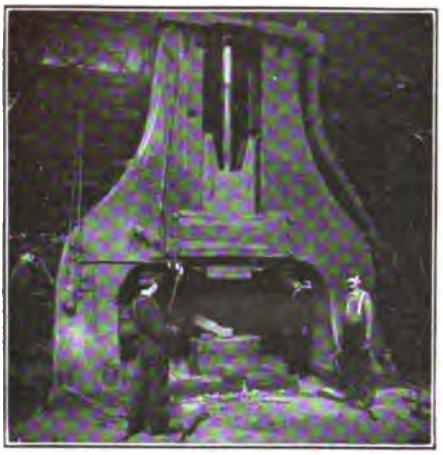

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Fig. 107.—Huge trip hammer in steel mill, Pittsburg, Pa.

However, the old type blacksmith shop will continue to exist, especially in rural communities, as long as horses and wagons are used. We still find the blacksmith shoeing horses and making the same general repairs on wagons and other things as formerly.

The extensive use of the automobile has in many cases resulted in the disappearance of the village blacksmith shop for the automobile garage. There is not a great deal in common between these fields of work, yet very frequently the blacksmith has been able to change to garage work.

Also, with the developments of the machine trade, hand forging is rapidly disappearing. The forge shop of a modern industrial plant does not show the smith standing beside the forge with his hammer and tongs but rather shows rows of machines. These machines are fitted with special forms against which heated metal is run in the shape of bars, or rods, or beams, and pressed to shape. The work of the forge man is involved in the operation of these machines. This includes in a measure the care of the machine, the proper adjustment of the correct templates, and the placing of the heated bar or rod against the templates so that it will be stamped or pressed to shape. The work of the steam hammer man is the most spectacular in the shop and is one of the most highly skilled trades. There are a few men who still do hand work on special pieces of work for which no machine has been devised, but these pieces are in every respect ones that are not made in duplicate and of which only a few may be required. The man who does this hand forging must know about the operation of the forge, the building and keeping of the fire, the proper

Fig. 108.—A large hand-forging shop.

heating of metal, and must have the skill necessary to shape material by hand. The blacksmith's work is rough and is usually heavy work, but in the large shops we find all sorts of hoists and cranes installed to lighten the work. The work is not unhealthful, nor particularly dangerous. Frequently, men are burned by hot metals, but usually this is not serious. The forge man in the big shop works from eight to nine hours per day, while in the smaller shop and general shop the day may be considerably longer.

The wages in the large shops run from $4.00 to $6.00 per day, but are rather variable in the smaller ones. The trade is in part recruited by the apprenticeship system and also by the helper system. Three to four years constitute the term of apprenticeship, where the boy's wages may vary from $1.00 to $2.50 per day. The line of progress for the boy or the mechanic is from apprentice through the journeyman stage to the foremanship and possibly superintendent. In the small shop, the opportunities for advancement are rather limited, but we find many instances where a man has worked up and established a shop for himself. The work does not require an extensive outlay for equipment and, in this respect, there is an unusually good prospect for the competent workman.

104. Boiler-Making.—The work of the boiler-maker consists of laying out, shaping, bending, flanging, assembling, and riveting together plates to form a shell within which tubes or flues are placed. It also takes up the making of smokeboxes, dampers, funnels, casings, and necessary fittings. Tank making is another branch of considerable importance, sometimes considered, although it is outside the range of boiler-making. The stages or steps involved in the making of boilers consist of first laying out the plate to proper size and shape, then laying off rivet holes and centers for connections, after which the boiler plate is taken to a punch machine, usually by means of a crane, and all holes are punched. Then the plate is moved to the shearing machine, where it is cut to proper size and shape. Most of the boilers are cylindrical in shape and, in order to secure this form, it is necessary that the plate be run through heavy rollers. The rollers are so set and regulated that the plate is turned so that it comes out at a certain diameter and is then ready for the fitter. The plate is then so chipped or planed that a certain kind of joint can be made. A butt strip, which is a strip of metal, is placed over the joint, and holes are bored through it that match with the holes in the plate, following which a few bolts are placed in the rivet holes to hold the joints together while it is being riveted. The rivets are heated

red hot and the headed end of the rivet is placed on the inside of the cylinder and the rest of the rivet projecting through the plate is headed up. This requires that one man must be on the inside of the shell holding something against the head of the rivet while the projecting part of the rivet is flattened out. After the riveting is done, the tube sheets are usually placed in each end of the cylinder. Tubes, which are similar to pipes, are then passed through the sheets and the ends turned over on the outside of the plates. These tubes are used to carry the heat through the water which surrounds them and which is heated by the hot gas or flames passing through. The smoke box and fire box and other parts that are made in the boiler shop are now placed in position and riveted on. The edges of the plate are shaped and the joints calked so that everything is tight and will withstand the pressure of water or steam. The bolts are then placed in the box and the machinist sets the valves and gauges. There are several different types of boilers, such as stationary, locomotive, and marine. They vary a great deal in appearance, but, in the main, the process involved in building them is similar.

The boiler-maker's work is heavy, as the plate metal with which he works is usually thick and very awkward material to handle. There is always a great deal of noise in a boiler shop, due to the hand or machine riveting. Other than the work being heavy, it is not extremely dangerous. A good physique is very necessary for this work.

Boiler-makers work from eight to nine hours, and, also, at the present time, have an opportunity for considerable overtime work. This is largely due, at the present stage, to the immense building program being carried out by the United States Fleet Corporation. All large boiler shops in the country are extremely busy on marine work. The boiler-maker's wage averages from $4.00 to $6.50 per day.

The trade is recruited almost entirely through the apprenticeship system. The boy as he starts in the work is usually from 16 to 17 years of age and the first job he encounters is the heating of rivets. As he heats the rivets, they are passed by a helper to a holder-on, who holds the rivets in position for the riveter or riveting machine. The apprentice, although only heating, gains from observation a rather thorough knowledge of the stage through which the rivet goes during the heating process. Usually, the boy's next step is that of reaming, followed by drilling, and then he is advanced to the riveting machine. He spends considerable time in what is called patching, which is the closing of holes or leaks in old or new boilers. No trade work of this nature is given in school at the present time and very few of the boiler-makers are recruited through

the helper system. A boy's chances or opportunities for advancement are from skilled journeyman to a foreman, and again from foreman to superintendent of that particular department. In order that he may successfully cope with the problems of a foreman or a superintendent, a technical school training, such as may be received in a high school, should be had, and should include shop mathematics, drawing, strength of materials and information concerning steam engineering. Most workers in the trade at present are not more than eighth grade graduates, and their chances for advancement are limited. The boy who prepares for advancement in this work, and has had the practical experience in the trade, may well expect promotion.

105. Shipbuilding.—Shipbuilding is a many sided task and requires mechanics skilled in more than 30 trades, besides an army of unskilled workers. It requires almost as many men engaged in trades that provide material directly for shipbuilders as are required in the shipyards proper. At present 300,000 men are at work in the shipyards and 250,000 are engaged in providing materials.

Fig. 109.—Constructing wooden ships.

In shipyards, the skilled workers who are doing the work on steel ships are shipfitters, blacksmiths, riveters, chippers and calkers, drillers, plumbers, pipefitters, machinists, joiners, carpenters, pattern makers, foundrymen, coppersmiths, heavy forgers, steel metal workers, furnace men, shearers, punchers, anglesmiths, shipwrights, riggers, flangers, drop forgers, erectors, boltersup, crane operators, locomotive engineers, firemen, loftsmen, painters, and helpers in all these trades. Sixty per cent of all the work on a ship is in constructing the hull, and the remaining forty per cent is installing mechanical parts, deck furnishings, and other equipment that goes to make the finished vessel.

Each trade mentioned contributes in making a finished product, and without any one no complete ship could result. Loftsmen, however, play a great part.

Ship plans are first made in a drafting room on a small scale.

The plans are then taken to the mould loft, which is a large building with a smooth floor of sufficient size to have drawn upon it the plans of the ship full size. The loftsmen fashion the templates or moulds of light wood or paper from which the steel for the hull can be laid off and marked for shearing, punching, planing and other operations.

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Fig. 110.—Steel shipbuilding.

The moulds are made from three plans that give shape to the ship. These plans, showing the lines of a vessel, are the sheer plan or side elevation, the half breadth plan, and the body plan or end elevation. The body plan is most used in making the moulds, for it shows better the shape of each frame, beam and floor plate. The moulds must be absolutely correct so that they will join together properly.

The shipfitter is probably the one metal worker whose trade may be termed purely a shipbuilding trade. He marks off the steel material for the parts of the vessel's hull, by fitting the loftsman's mould over the steel. Drillers also play a big part in the drilling and reaming of holes. They are necessary, because the rivet holes, being punched in the shop, do not always coincide, despite careful workmanship. In some cases, also, holes must be drilled on the ship. The unevenness between holes is removed by reaming, which is merely a slight enlargement.

Perhaps riveters do the most spectacular work. Riveting holds the ship together, and a ship's plans specify every rivet, for each has a certain function. Chippers and calkers trim off or smooth the edges of plates, castings and other parts and make them water tight. Shipwrights install the wooden decks, masts, spars, and booms. Other ship woodwork is done by joiners.

Ventilation, piping and light metal work is done largely in the shop by sheet workers. Plumbing and piping also is done in the shop by plumbers, machinists and pipefitters.

Shop work on the hull proper is done by workmen operating

shears, punches, bending rolls, planers and other machines, and the frame benders, acetylene burners, furnace men and anglesmiths who perform the preparatory work to the erection of plates, brackets, clips, beams, bulkheads and parts required for the hull of a ship.

106. Steel and Rolling Mills.—Steel and rolling mills depend for their raw material upon the iron mines. The iron ore, the greater part of which comes from what is called the range in Northern Minnesota, is largely mined in open pit mines. It is carried by means of cars to

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Fig. 111.—A big steel mill near Birmingham, Ala.

the iron ore docks at the head of Lake Superior, where it is quickly loaded from the docks into the holds of large ore barges and conveyed to the blast furnaces. A blast furnace is a tower, usually about 80 feet high and 20 feet in internal diameter at its widest part, narrowing somewhat both toward the top and bottom. The walls are built of steel and lined heavily with fire brick. When the ore reaches the smelters, the blast furnaces are charged by means of what is called a skip, which takes the raw iron ore, coke and flux up to the top of the furnace and dumps it at intervals into the furnace through the cone shaped top. Here it is subject to intense heat, secured by rapidly burning the coke by means of a hot air blast. The ore is fused and the molten iron flows to the bottom of the furnace where it is drawn off at the tamp hole.

Many men are employed around the blast furnace, each with very definite duties. **Stockers** have as their duties the shoveling of ore

from the cars, dumping hopper cars, breaking ore and other materials, and tending the bins.

The **bottom filler** transfers material from the stock bins to the furnace hoist. The **top fillers** are responsible for the dumping of material at the top of the furnace into the hopper or cone. The **larryman** operates a small car which delivers the ore and fuel from the stock bins to the skip cars. The **skip operators** are the men who operate the car which runs up the inclined way to the charging platform of the smelter. Men, called **blowers,** are responsible for the proper amounts of materials which go into the furnace, the pressure and temperature of the blast, and the time and manner of tapping. They have the greatest responsibility of all the workmen in the immediate vicinity of the furnace. The drilling of the hardened clay from the tap hole is usually done by a helper. The **dumper** directs the flow of the metal into the ladle or into the sand bed and, after the cast, directs the work of closing the tap hole with clay. In the modern plants this is accomplished by operating what is termed a mud gun.

Pig machine men take care of the iron molds which are mounted on endless chains into which the molten metal is poured from a ladle. They are sized by men who see that the trough from the ladle to the molds is kept clear, and by **lime men** who spray lime or clay into the iron molds to prevent the metal from sticking. When the metal is poured into the molds on the floor, the **loaders** carry the "pigs" from the floor to the yard or load them on cars. All of the work in connection with the blast furnace is heavy, and many of the men are subjected to intense heat.

The wages of blast furnace men, especially those requiring skill and experience, are good. All the men work long hours, as the blast furnace is operated 24 hours each day for seven days in the week. In places, 12 hours constitute a day's work.

The pig iron is the first stage in the converting of the raw material into a metal adapted for use in machines. Much of the raw pig iron goes to the steel mills where it is subject to processes in either the Bessemer converter or an open hearth furnace. A great deal of the work in these two fields is low grade labor and large numbers of foreigners are used. A small number of highly skilled men are required in both processes. This work is dangerous as there is the hazard of being burned, especially during the process of tapping.

The metal, as it comes from the converter or the open hearth furnace, is usually in the shape of an ingot. It goes to the blooming

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Fig. 112.—A great converter in big steel mill near Pittsburg.

mills where it is shaped into what is called blooms, billets or slabs. This is merely an unfinished product, which, in turn, may be sent to the standard rail, plate, rod or wire mills, which turn out a finished product. The first operation through which this ingot goes is that of heating which is done in a pit. After it is heated to the proper temperature, it goes to the rolls. The heated mass of metal is fed into a series of live rolls which draw it out into a rough shape. All the time the metal is being drawn out, it is a hot mass, and, as the roll man, manipulator and table man, and shear man work with the bloom, they are subject to a great deal of heat. The bloom leaves the mill and then may go into one of the types of mills mentioned above. If it goes to the plate mill, it is again heated and rolled out into a plate of the proper gauge or thickness and is cut to shape.

Much of the material goes to what is called the standard rail mill where it is heated again and fed into rolls which give it the shape of the common rails or beams. Again, much of the metal is used for bars. Before this stock can be fed into rolls, it must be heated, and, by means of a series of rolls, is gradually drawn out to the desired shape. Some of the bars may be round, some are octagonal, and many are square. As this material, whether it is rails or bar stock, is passed through the rolls, which move at a rate of speed in some instances as high as 30 miles an hour, very close and careful attention is required on the part of the workers to see that the material moves clearly, otherwise trouble is encountered. Much of this metal material is also worked up into the form of sheets or tin plate. The processes involved are similar to those already described. The main process is one of shaping material between the rolls until the proper thickness is obtained. Then there are the shearing processes which cut the stock or sheets to the proper dimensions.

The hours and wages of the majority of men engaged in this whole industry are rather low, since many of them are simply in the

laboring class. Those requiring a high degree of skill receive good wages. All of them work long hours and under conditions that require a robust physique.

There is no definite period of organized apprenticeship. In most of these fields the man advances from one stage to another by observation and actual experience in the mills. For the young man entering as a laborer, who will devote himself to study, there is an opportunity to work up to a foremanship and to even more responsible positions. The lives of some of our most successful steel men point out what has been possible and is still possible in this field.

107. Sheet Metal Workers.—Tin smithing or sheet metal work has developed rapidly in the past few years. Metal in some form is taking the place of wood in many of our most commonplace things. The work of the sheet metal man consists primarily in laying out tin sheet metal, the forming and making of water spouts and gutters, the laying of tin roofs, erecting metal ceilings and side walls, metal fences and skylights, and covers for fire doors and windows. The daily work of sheet metal workers does not involve any particular physical or nervous strain. The materials are reasonably light and at the present time machines are used for much of the work.

To successfully compete in this trade, the worker should have more than a mere knowledge of the manipulation of the tools and materials. Much of the work involves laying out of the work, which demands the use of a large number of geometrical constructions. Ability to lay out work is something that many of the practical workers lack, and is the feature that marks the difference between the ordinary worker and the high class mechanic. The different shapes into which metal is formed, as cornices of buildings, gutters, systems of ventilating pipes and connections, and ventilating blower systems show some of the problems that the mechanic in this field has to meet in laying out work. The cutting of the metal is done in part by hand and in part by machine, the heavier metal in all cases being machine cut. The shaping is also done largely on machines, the riveting and soldering being the two aspects that are usually done by hand process. The hours worked by the jour-

Fig. 113.—A sheet metal shop devoted to construction of pipes, tanks and similar work.

neyman average from eight to nine in practically all parts of the country. The wages vary considerably, but the daily wage for a first grade mechanic will average probably between $4.00 and $5.00. In some cases the work is affected by the seasons, the employment fluctuating about the same as with the other workers in the building trades. If the worker is employed in a large shop, in many cases the employment is steady the year around. The trade is recruited by means of the apprentice system in the majority of places in the country. There are always a few who come into the trade through the helper stage. The average wage of a boy during his first year of apprenticeship is from $4.00 to $6.00, second year from $6.00 to $8.00, the third year from $8.00 to $12.00 and the last year from $12.00 to a rather variable sum. A boy to successfully work in the trade should know something of pattern drafting, free hand and mechanical drawing, and should have a knowledge of architecture and geometrical forms, and shop mathematics. An eighth grade education does not fully provide this. A boy who has finished high school, and especially a technical course, has a good preparation for successfully working in this field. As in all shop trades, the logical line of advancement is from a journeyman worker to a foremanship, and from a foremanship to a shop owner. Since there is a growing demand for metal work of this character, a man who has had the necessary preliminary training, and has accumulated a little capital is in line to move ahead and establish a shop of his own. To do this does not require a large initial outlay of capital which is one advantage of this particular trade. Success as a shop owner will depend in a large measure upon the character of the town and the demand for the products of a sheet metal worker.

108. Automobile Repairing and Garage Work.—The automobile has to a large degree, taken the place of the horse and wagon. With a constantly increasing use of this means of conveyance, within the past few years, a comparatively new occupation has sprung into prominence. The mechanical equipment of an automobile, with its delicate adjustments, driven by people, in many cases, not at all familiar with their mechanism, has resulted in the need for this field of work. Automobile repairing and garage work is now a common occupation. Almost every village possesses a garage, and in the large cities they may be found in practically every block. The automobile repair man is called upon to make all sorts of repairs and adjustments to all types and kinds of machines. One hour he may be working upon an electrically driven machine, a little later, upon a 12 cylinder gas machine, and possibly within the same day

upon a steam machine. If he works successfully, he should be acquainted with all types of engines, and the kinds of ignition and transmission, all of which cover a wide range of mechanical work. He may be called upon to make repairs and adjustments to the starter, or a car may have an axle sprung and come into the garage for repair. Very frequently tire trouble demands attention. When all these features of the work that the garage man is expected to repair are considered, the amount of training and experience necessary to do this work successfully is realized. At the present time there is a shortage of skilled men who are competent in this work, and, consequently, high priced cars are being overhauled by men not competent to work upon them. Owing to the shortage of men in this field and the large number of machines in use, in many cases the hours of the garage people are long and uncertain.

Competent workers in most places are paid good wages. There is no organized system of apprenticeship to prepare mechanics for this field. There are numerous schools throughout the country, both public and private, which are preparing automobile mechanics. Many boys go into the work through what we might call a helper's stage. They have some little mechanical ability and are taken on by the shop and trained to do the general work demanded in the shop. This type of training is not entirely successful, because, while it may be practical, it is lacking in the theoretical aspects that are essential in making repairs intelligently on delicate machines. The work is rapidly growing in popularity in high and technical schools, and in the future young men may be expected to enter this work better qualified. The theoretical work, and also some practical experience gained in the school shops, will provide young men with the necessary information to make a start. The use of the automobile will undoubtedly grow, and the entire field offers one of the best opportunities for a young man, technically inclined, to engage in a work requiring a high degree of skill. It also offers an opportunity for him to establish a garage of his own. In many places a garage is carried on in connection with a sales agency, and the work offers a bright prospect to one equipped to enter it. The young man should not lose sight of the fact that training beyond the eighth grade is almost essential for successful participation in this industry.

109. Stationary Engineer and Plant Operator.—There is a big demand for skilled men able to operate and keep up a steam plant. A few years ago the opportunities in this field were limited, but every year witnesses tremendous growth of industrial plants and the introduction of power of some kind for light, heating or machine operation.

These plants range all the way from a few hundred horse power to thousands of horse power as found in the huge rolling mills and other industrial plants.

The work of the engineer requires that he have a thorough knowledge of heat and steam, fuel, boiler installation, and the economic management of his entire plant. His knowledge must include the practical experience necessary to make repairs on the engines and boilers. Besides, his work requires that he should be proficient in the knowledge of dynamos and motors. Today, in almost every plant, is found a very extensive use of electricity, so it is necessary that he should be familiar with both steam and electricity. On the practical side of his work he should be able to handle any type of repair work, both on steam and electrical units. Many times he is called upon to make emergency repairs which require a high degree of ingenuity. If the power is shut off in a huge manufacturing plant, hundreds or thousands of workers are held up in their work and this means a huge loss; consequently stationary engineers or plant operators hold a most important place in the productive side of industry.

Fig. 114.—Operating a large power plant.

The wages of the engineer vary and range all the way from the man who operates a small plant, receiving possibly $75.00 or $100.00 per month, to the man who is entrusted with the responsibility of running a huge plant of seventy-five thousand horse power.

In many cases the hours of the engineer are more or less irregular. If the plant is in first class condition and his work carefully organized, his day probably moves in a regular way. Frequently, the modern plants, running under high pressure, require close attention and long hours on the part of the engineer to keep the equipment in first class condition. There is no regular period of apprenticeship for the beginner in this trade, but frequently the future engineer has his start as an assistant or probably a fireman. He gains first hand knowledge of how to fire a boiler and becomes thoroughly acquainted with conditions around the plant. From the position of fireman, if he is ambitious, he passes to the stage of assistant engineer, then to the day or night engineer, and then, finally, if he is prepared for it, to that of chief engineer, with all the responsibility pertaining to that particular job. The work of the engineer is not dangerous,

hygienic conditions are usually very good, and there is nothing in connection with the work that is a detriment to normally healthy individuals.

A technical training is a very decided asset to any young man taking up this work and will be one of the factors that insures success.

FOOD MANUFACTURING AND ALLIED TRADES

110. Milling.—Most of the workers in this industry are employed in flour and feed mills, while a small portion work in cereal factories and grist mills.

To produce fine white flour from the wheat kernels requires several processes. The first is the cleansing of the wheat. Receiving separators, consisting of large sieves, separate foreign matter, such as lint, weed, seed, and sticks, from the wheat. The wheat is then put into storage bins, and, when needed, drawn to the mill separators, where foreign matter is further removed by scattering the wheat grains on moving perforated iron screens. The wheat is scoured in another machine, and, by a special device, cockle seeds are removed. Some millers prefer to wash their wheat and dry it again, but most of them do not consider this necessary.

Fig. 115.—A modern flour mill.

After the cleansing comes the tempering. There are many methods employed in tempering, but the principle in all is to soften the grain by means of heat and moisture. Then it is ready for grinding. The outer coats of bran are separated from the middlings and the part of the wheat desired for flour. This is done by repeated rolling and sifting. The bran is used for cattle feed. The middlings are purified, pulverized and bolted, the entire process being known as reduction of the middlings. The bolter machine contains some three hundred and sixty sieves made of silk bolting cloth of varying mesh. With a rotating motion, from 8 to 12 separations of the material are made. Coarse parts are again sent through the purifier and roller until fine white flour is produced ready to be packed into bags or barrels. The germ is removed early in the process because, if left in, it would impair the keeping quality of the flour and give it a yellowish color.

Milling is an industry using a comparatively small number of workers to make a very valuable product. In Minneapolis, the city producing the largest amount of flour and grist mill products in the world, it has been estimated that the value of the output per worker is 13 times that of the foundry and machine shops of the city. This is true partly because the raw material costs so much, and partly because of the improved processes of manufacture.

The workers encounter no particular physical or nervous strain. The noise in the grinding department is confusing, but the men soon become accustomed to it. Only men with sound lungs should work in wheat storage and cleaning departments on account of the dust. On the whole, the men who have been in the trade a long time appear to have thrived and to be in good health. The number of accidents is low.

The general working day in the mills is 8 hours, but in most places, sweepers, loaders and packers have a 10 hour day. There are three shifts and some find the night work unpleasant. Flour making is carried on throughout the entire year, but May, August, January and February are the slack months, when some of the unskilled laborers are laid off.

Nearly all of the productive workers in the mills can be trained on the job in a very short time. In most cases it is not necessary that the men even know how to read and write. **Sweepers** and **oilers,** jobs from which there is rarely promotion, are usually foreigners from 40 to 45 years of age. The **loaders** are younger men, usually under 30, and should be heavy and strong, but no other qualifications are necessary. The wage in these departments varies from $2.10 to $2.40 a day.

Elevator man is a step up, and he must know how to read, write and figure in order to keep simple records. He must be able to detect trouble in the machinery, and see that the wheat is shunted into the proper bins. The **loader foreman** has charge of unloading wheat from the cars. He should be able to plan the moving of the cars, keep simple records, and direct a gang of men, the latter asset being particularly important. The wage will run from $2.50 to $3.50 a day. The **elevator foreman** has general supervision over the elevator, keeps records of the receipts, tests, and disposition of each lot of grain received. This is the most important position in the department and requires executive ability and training. He must be able through experience to grade the wheat correctly, to know weights and measures, and to figure percentages.

Grinders and bolters hold the most important productive positions in the mills. Most of them are men between 40 and 60 years of age, and they receive about $3.38 for an 8 hour day. They must know the

routine of their work and be able to adjust their machines correctly. Few of them know much of the theory of milling or have much mechanical knowledge even concerning their own machines. The **second miller** needs to be familiar with every detail of the work, able to plan ahead, direct others and keep records. These men work from 8 to 10 hours a day and receive from $3.36 to as high as $8.00 a day, for 10 hours' work. Of course, the best position is that of **head miller,** and it requires a combination of qualities of leadership and experience in the trade and a fair education to fill it well.

Flour is constantly tested to see that it is up to the advertised standard to keep the output uniform. Many of the men doing this apply only physical tests, but the larger concerns employ **chemists** as well. A **baker** is also employed to further check or test the flour.

The **millwrights, carpenters** and general laborers, including **plumbers, plasterers, steamfitters** and **machinists,** form an important unit of a large flour mill. They keep the machinery in running order and make repairs. The machinists come largely from promoted helpers and laborers inside. The others are drawn from outside sources. Wages range from 25 cents an hour for helpers to 40 cents an hour for millwrights. Next to the head miller, the millwright is the most able man in the plant. Usually he has little education but has grown up in the mill.

In milling, there seems to be about one desirable position for every 10 unskilled low wage positions. The smaller mills train the workers for the large concerns. The theory of milling and technical and mechanical training in connection with the trade are taught in a few colleges but nowhere in the lower schools of the United States.

111. Baking.—Baking has been one of the essential industries since the days when women ground the meal in a hand mortar, mixed it with water and salt, and baked it on hot stones before the fire. From this crude beginning, development has been made to the place where a number of baking companies have grown to be immense concerns, employing thousands of people.

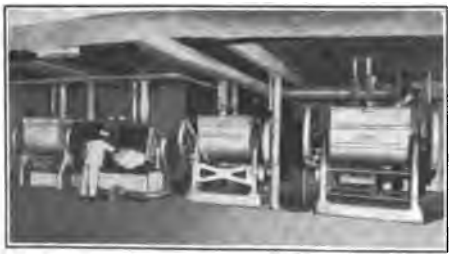


Fig. 116.—Bread mixing machines in a large bakery.

In the large bakeries, practically all operations are performed by machinery—in fact it is the boast of one well known concern that no hand touches its product until after it has been wrapped and sealed. They are

models of cleanliness and sanitation, a great advance from the dirty basement cake-shops of a few years ago.

There are five departments in a large city bakery: storage, mixing and dough, kneading, baking, and packing and shipping. The raw materials are made into dough by electric bread mixers, a process requiring about 25 minutes. The dough is then turned into the raising trough for about 3 hours, after which it is automatically carried to the machine which weighs and cuts it into uniform pieces. It is then passed on a moving platform to a number of kneading devices which roll and press it into shape, after which it is allowed to rise again. The baking department takes care of the actual baking which must be carefully done. The **foreman** of the plant has charge of these three departments, the storage room being in charge of a **stockkeeper** and the packing and shipping under the direction of the **chief clerk.**

In a small bakery, from one to four men are usually employed, the work often being done entirely by hand. The same man may mix, knead, bake and deliver the bread. It is readily seen that it takes a much better trained man to handle a small bakery than it does to fill the majority of positions in large bakeries.

Beside the large bread bakery and the small bakery which probably makes bread and simple rolls, we have also the cracker factory, which is quite a separate industry, although managed in much the same way as the large bread bakery, and the cake shop.

The cracker industry has grown very rapidly. One American concern now puts out over 400 varieties. There is no food industry which uses a greater number of foodstuffs from so many parts of the world. Crackers are divided into sponge, sweet, and iced goods. Soda crackers are an example of sponge goods, while there are endless variations of sweet and iced goods, according to the ingredients and the way in which they are mixed. These products are put up in moisture-, dust-proof packages, and enormous quantities are sold. The ovens in this type of bakery are particularly interesting. They have an arrangement of shelves resembling a large Ferris wheel, each shelf in turn coming opposite the door of the oven to be filled and emptied.

Fig. 117.—Bread ovens in a city bakery.

The cake shop practically duplicates the small bakery, the work being done mostly by hand, the product being cakes of various kinds.

There are comparatively few positions in the large bakery that require much training, education or skill, or that pay very high wages. Most of the operations can be learned in a week's or a month's time from some older hand. Usually two shifts of ten hours each is the rule, while in the small bakery the hours are longer. The wages of the ordinary workers are from $10 to $20 a week; the **assistant foreman** and **head mixer** receive $960 to $1,200 a year, while the foreman will receive from $1,800 to $5,000.

The demand for well trained workers exceeds the supply. They are recruited from several sources, some of them coming from the old country, some from the yeast companies, others just drifting in for a job. The best trained men are usually foreigners, and, unfortunately, they find it hard to adjust themselves to our American machinery.

The trade is not considered at all dangerous. The mixer needs to have good lungs, working with the flour as he does. The **oven men** must be able to lift considerable weights.

Promotion is apt to be slow and is along no very systematic line. The stockkeeper is seldom transferred from that department; **pan cleaners** and **sifters** may become machine tenders; **bench hands** may be promoted to oven tenders; occasionally an oven tender may become foreman; or more likely an assistant mixer becomes head mixer, and the head mixer becomes foreman. Often outside men are brought in for important jobs. A small shop is often opened in a city or small town by the ambitious man.

It is quite necessary that the head mixer and foreman, at least, know every step of bread making and understand something of the chemistry of it, also, that the foreman know how to handle men, and be familiar with business management. Much of the prosperity of the bakery depends on the foreman being able to well organize and systematize his plant and keep up with new ideas and devices. A knowledge of chemistry and business methods would be substantial aids in helping members of the trade to advancement. There are a few schools throughout the country which now offer courses in baking.

112. **Butchering and Packing.**—The slaughtering and meat packing business is one of the largest industries in the United States. It centers naturally in those cities which are surrounded by wide grazing areas and which have good transportation facilities. Chicago, Kansas City, Omaha, St. Joseph, St. Louis, Fort Worth, and Indianapolis are leading meat packing cities. Artificial refrigeration and

(By U. S. Dept. of Agriculture.)

Fig. 118.—Inspectors at work in a packing house.

the much increased use and number of by-products have been important factors in the growth of the industry.

The large modern packing houses consist of many departments. All stock is inspected for disease as soon as it arrives at the plant. In the thoroughly modern packing plant, the cattle are usually taken to the top floor or slaughtering pens in huge elevators. Following the killing, they are bled, the hide, head, feet and internal organs are removed, and the carcass is thoroughly washed. Government inspectors examine the meat and internal organs for disease and then stamp the meat, if it is suitable for human consumption. The meat is then sent to the refrigerators to cool and await shipment or other disposition.

The by-products follow a regular course, working down from the top floor to the bottom one, coming out as a raw material in some cases and in others as a product ready for immediate consumption.

Hides of beef are the most valuable by-product. The men who remove them are skilled workers. The pelts of sheep and the bristles of swine are also removed with care and cured by salting. Fat is the second in importance as a by-product. The rendering of fat from hogs is one of the most important processes carried on in the packing houses. Bones of the head and feet furnish many useful products, such as bone black, oil for leather dressing, black pigment for paints and shoe blacking. Knife handles, buttons, fans, combs, and similar articles are made from bone, while some of it is ground up for fertilizer.

(By U. S. Dept. of Agriculture.)

Fig. 119.—In the smoked ham department.

The tankage or residue of meat scraps, left after the fat has been extracted, is used for fertilizer. The chief sources of glue and gelatin are liquids, in which

cattle and sheep's heads, feet, hide, trimmings, sinews and bones, calves' heads, and pigs' feet have been boiled. Many different grades are obtained.

Many varieties of sausage, bologna and similar products are made to dispose of the portions which would be unpalatable in their original condition. Chipping dried beef, curing and smoking hams and tongues, and making pepsin and meat extracts are other branches of this great business.

113. Butter and Cheese Making.—Until comparatively recent times, butter was a household product. With the advent of the creamery, butter making became part of a special industry. Methods and machinery have improved rapidly until now a uniform quality of the product is assured.

Fig. 120.—A creamery.

The processes followed in extracting fat from milk and transforming it into butter are as follows: separation of the cream, churning, washing and working. Butter is usually salted, but some prefer the sweet taste. In continental Europe, sweet butter is used almost entirely and is purchased fresh every day. The color and flavor of butter varies with the care of the cows, their feed and the season of the year.

Renovated butter is made of aged, rancid butter that is melted, strained and purified. The mass is then rechurned with fresh milk, colored and reworked. Such a product is inferior to fresh butter.

(By U. S. Dept. of Agriculture.)

Fig. 121.—Making butter in a Wisconsin Creamery.

Oleomargarine, while the flavor is not so fine, furnishes a thoroughly wholesome, cheap substitute for butter.

New York and Wisconsin produce large amounts of cheese, but as a nation we consume much less than the Europeans.

Cow's milk is the basis of most cheese, although the milk of the ewe and goat is used in the old countries. An enzyme called rennet is added in the manufacture

of some cheese, thus causing the separation of the curd and whey. Cheese is divided into two general classes, hard and soft. Examples of soft cheese are cream, cottage, Limburger and Neufchatel, and examples of hard cheese are, Stiltion, Cheadar, Edam and Roquefort.

114. Canning.—The importance of canning as an industry is shown by the following table taken from the Indianapolis, Indiana, Survey for Vocational Education (page 207):

	Value of Output for 1914
Fruits, vegetables and canned soups	$158,015,893
Salmon, estimated	30,000,000
Milk, estimated	60,000,000
Meats, estimated	15,000,000
Sardines, estimated	6,000,000
Shrimp, oysters, and other sea food	3,000,000
Total	$272,015,893

Fig. 122.—A pea grading machine.

It is most important that products for canning be delivered fresh and in good condition. Contracts between growers and canners are the first step in the industry. On arrival at the canning factory, raw material is graded on the basis of its condition, size and quality. Then treatment of the fruits and vegetables begins. Apples must be peeled and cored, tomatoes peeled, corn husked, peas shelled, and each product prepared in the proper way. Some of this is done by machinery, but mostly by women and girls. The cleansing is done by machinery, by means of soaking and spraying. The cans are run through a washing machine before use.

Fig. 123.—Filling machines.

Most vegetables and some fruits require dipping in boiling water for a few minutes, which is called blanching. Cans are filled both by hand and by machinery. In the finer selected grades of goods, the cans are filled by hand. Sauces, syrups, water and brine are

added after the cans are filled. Thus far all the work is done by unskilled labor.

Processing or sterilizing consists of heating the product to a high temperature for a sufficient length of time to kill all forms of bacteria and spores. This work is supervised by expert men and various devices for timing and recording temperature are employed. Exhausting the air from the can and sealing it are the next steps.

Fig. 124.—Capping machines soldering lids on 12 cans at one time.

From 40 to 75 cans per minute can be sealed by the double sealer machines. The operator is a skilled worker. Rapid cooling in tanks or by spraying gives uniform color and quality to the product.

Usually labeling is done by girls, either by hand or with the aid of a machine. The boxing, which is heavier work, is done by men. Both labeling and boxing are ordinarily done in the slack season.

This is perhaps the most seasonal of all occupations. August, September and October are the busy months. A few factories handle a sufficient variety of products to run throughout the year, increasing the force somewhat during these months.

Fig. 125.—The "processer" or steam cooker.

The workers, as a class, are unskilled and the wages are poor. Housewives in the vicinity of the plant and school girls furnish the majority of the workers.

Wages range from 15 to 25 cents an hour, peelers making from $1.00 to $2.00 per day. The desirable positions are few. Skilled men supervise the cooking departments. Occasionally there is opportunity to work into higher executive positions. One of the best outlets is to get into the selling end of the business. Since the industry is seasonal to such a large extent, the work somewhat unpleasant and poorly paid, the outlook for workers is extremely limited.

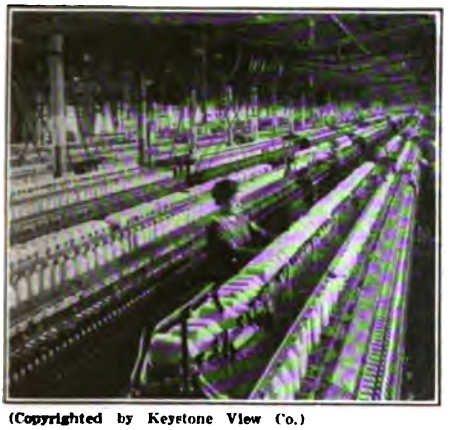
115. Candy Making.—The demand for confectionery is constantly increasing. Sugar and glucose form the basis for most candies, to which are added flavorings, colorings, nuts, chocolate, and various other materials.

Candies are divided into two general classes, hard, of which stick candy is an example, and soft, as bon bons, creams and similar kinds.

Some of the largest factories employ from 300 to 500 workers, mostly girls, and their output during the busy season before the holidays may reach a million pounds per week. The most responsible positions are held by men. The chocolate work is usually considered as requiring the most skill. In the large factories, a chemist is employed who is constantly in search of new flavors and new combinations. The necessary skill for almost all the work is acquired on the job. The only really desirable positions are the executive positions, such as foremen, superintendents, buyers, and salesmen.

TEXTILES AND THE CLOTHING TRADES

116. Textiles.—The four principal fibers used in the manufacture of textiles are cotton, flax, wool and silk. The manufacture of cotton cloth on a large scale was made possible by the invention of the cotton gin. This machine enabled a sufficient amount of cotton lint to be supplied to the spinning and weaving machinery. Cotton reaches the mills in the form of bales, and must go through many processes before the yarn is spun and ready to be woven into cloth, made into thread, or knitted into cotton underwear and hosiery. There is a wide variety of cotton fabrics manufactured, gingham, muslin, percale, nainsook, duck, chambray, and calico being some of the most common. Cotton yarns are put to many uses. The knitting industry uses large quantities, while thread, tape, belting, shoe laces, braids, bindings, and lace making require large amounts.



(Copyrighted by Keystone View Co.)
Fig. 126.—Spinning cotton yarn in great textile mills in Massachusetts.

117. The manufacture of linen yarn, which is made from flax fiber, is one of the oldest industries. As in the case of cotton, machinery now prepares the fiber and spins the flax into yarn, and, finally, great power looms weave it into beautiful damask table linen and other fabrics so much admired. Linen is more expensive than cotton, has better lasting qualities, and is better appearing. Besides linen cloth, we have linen thread and fine lace. Cord, twine, and rope are also twisted from flax yarn.

118. Wool is the most important animal fiber. Raw wool requires much cleaning, after which it can be carded and spun into yarn, in a manner similar to other fibers. Two kinds of woolen yarn are

(Copyrighted by Keystone View Co.)

Fig. 127.—Gill machine drawing carded wool into yarn.

made, woolen and worsted yarns. In the worsted yarns the long straight fibers are combed to lie parallel to each other. This is an expensive yarn and from it are made high-grade worsted materials and underwear. Woolen yarn, which is made of short carded fibers, is felted and made into close woven beautiful broadcloth and similar fabrics. Shoddy or some of the other remanufactured wools are often used with the new fibers. It is necessary that this should be done, otherwise the cost of woolen materials would be very high, because not enough could be produced to meet the needs of the world. The addition of shoddy by no means spoils the product. Broadcloth, serge, cheviot, felt, tweed, and many other well-known fabrics are made from wool. It is used in the manufacture of carpets, rugs, underwear, hosiery, blankets, and for knitting shawls, sweaters, capes, and like articles.

119. Silk is the most expensive, the strongest and the most beautiful of all the fibers. Japan, China, Italy and Asia Minor, countries where labor is cheap, produce most of the raw silk. The cocoons produced by the silk worm are wound on a reel, and the reeled silk is made into hanks and sold by the pound as raw silk. The silk industry in the United States is engaged principally in the manufacture of the raw silk into silk thread and cloth. Some of the best-known silks are crepe de chine, foulard, satin, pongee, taffeta, moire, and velvet. Other uses of silk are for ribbons, embroidery silks, fishing lines, for insulating electric wires, and the manufacture of plushes, hosiery, underwear, and in knitting.

(Copyrighted by Keystone View Co.)

Fig. 128.—Weaving room in New Jersey silk mills.

Artificial silk has been manufactured to meet the demand for a lower priced article.

120. The Clothing Trades.—In the making of clothing, the following rather distinct divisions of the work may be made: men's and boys' clothing; custom tailoring; raincoats and waterproof clothing, cloaks, suits and skirts; ladies tailoring; dresses and waists; wrappers and kimonas; children's and misses' garments; woolen underwear; and corsets. Also, the making of gloves, hosiery, and caps and hats for men are separate divisions of the industry.

(Copyrighted by Underwood & Underwood, N. Y.)

Fig. 129.—Manufacturing men's clothing.

Certain occupations are common to practically all the clothing trades. The **designer,** who may or may not be the cutter, must know the styles, must know how to design a pleasing garment and cut patterns, must know materials, and, if cutting is done by him, must know widths and shrinkage of cloth, how to lay the pattern to best conserve material, how to match stripes and designs, and how to grade patterns for stock sizes. Considerable training and long experience are necessary.

The **spreaders** who lay out the material to be cut and the **markers** who mark carefully with chalk or pencil around the patterns are practically helpers or apprentices to the cutter.

Two years are usually considered the term of apprenticeship, but a workman seldom becomes head cutter in less than five years. The cutters stand nearly all the time and must have good endurance, good eye sight, and a steady hand to use the cutting knife. Cutting is done both by hand and by electric machines.

Button hole making is mechanical work, but requires constant attention, since button holes cannot be easily mended, if done wrong. This work is done largely by women and girls. Steady nerves are an asset, as the chopping sound of the machine is annoying. Hand-made button holes are used only on exclusive and high-grade products.

Button sewing is also now done by machine. The worker inserts a button in a slot in the presser foot and places the garment in position in the machine which does the rest. Buttons on overalls and similar garments are clamped into place.

The positions of **examiners** are filled usually by young workers, just entering the industry, or by older women who cannot stand the strain of pressing or sewing. An observing girl can pick up much information here, even though it does not prepare her for other work in the factory.

Pressing is done both by hand and by machine. The lighter weight fabrics are pressed with a hand iron, much of it being done by women. Men do most of the pressing on tailormade clothing and custom goods, as such work demands special training and skill. The pressing of hats and caps is also a special trade, a steam heated block of iron being used. The wages of apprentices, before they become top pressers, range from $8 to $12 per week. They may be paid either by the week or on a piece basis.

Packing requires neatness and care and a fair degree of endurance, as the girls usually stand. It is extremely simple work and can be learned in a few days. Men and boys repack the boxes into heavy cases for shipping.

In the making of working men's clothes, such as overalls, mackinaws, shirts, etc., the requirements for workers are practically the same as in other branches of the garment trades, except for fur cutters and sewers. The work is apt to be heavy, and good health and endurance are necessary. The sewing is simple and coarse, and little or no training or education is required.

The number of women who buy ready-made clothing has increased rapidly in the last few years. The custom-made product has been much improved, and accordingly dressmakers and women's tailors have decreased in number. Indeed, many of the former dressmakers now do the altering and refitting of the ready-made garments, either at home or in the department stores. The garments can be made cheaper in large quantities, more style is often achieved, and the bother is so much less that the habit of buying ready-made wearing apparel is growing.

A very large per cent of the work in the garment trades is unskilled and poorly paid. In the dress and waist shops, about 84 per cent of the employees are women and about 16 per cent men. Women are employed almost exclusively for assorting, cleaning, embroidering, finishing, draping and joining. A larger per cent of men work in the tailoring shops. Men are the cutters in almost all branches of the industry and do the heavy pressing and the custom pressing in most cases. It is undoubtedly true that a considerably large number of women and girls seek a living in this industry. It is also true that in general men do the more highly skilled work and receive the highest pay.

It is difficult to give actual figures since wages vary with the different branches of work and in the different sections of the country. Practically all the work that can be done on a piece basis is so organized. Beginners usually work for a short time on the week basis while learning and designers, cutters, some pressers, and other workers are on the week basis. For the dressmaking trades, the following figures give an idea of wages: Helpers, $2 to $6; finishers, $6 to $10; shoppers, $6 to $10; drapers, $8 to 15; lining makers, $8 to $10; fitters, $10 to $25 per week.

Most of the branches of the garment trades show considerable seasonal variation in employment. The busy season in many of them comes from the latter part of July to the end of October and from the latter part of January to the middle of April. This cuts down the yearly earnings of the workers to a serious extent. Some factories have tried dovetailing custom and trade work to make employment more regular throughout the year.

Thousands of workers crowd the field and the desirable positions are few. Designers, foremen and forewomen, buyers and salespersons may draw good salaries and have work that they enjoy. Starting in a small way in some specialized line would seem to hold a better future than getting caught in the whirlpool of the big factories. For instance, a girl with artistic ability and good business judgment might start in her home town the making of children's clothes of an unusual kind, and gradually enlarge her business. The only hope for adequate income and congenial work in the huge factories lies in advancing to the higher executive positions.

121. Millinery is a trade in which the workers are practically all women. A decided change has come about in the business in the last few years. Most millinery shops are no longer factories where hats and trimmings are made, but are display and salesrooms. The tailor-made hat has increased greatly in popularity, and only a small percentage of hats used in the more exclusive trade are now hand made. The millinery departments in the department stores have grown more rapidly than the small shops. The work is seasonal to a large extent. Girls usually begin as apprentices during the busy season. The demand for trained workers having skill and artistic ability exceeds the supply. Promising workers are sent to fashion centers and large houses to supplement their training. The wages of trimmers range from $15 to $40 a week, for twenty-six weeks. Designers' salaries vary more, probably from $25 to $50, from thirty to forty weeks in the year. Saleswomen are employed more constantly

at from $5 to $25 a week. Very good courses in vocational schools are offered in this subject.

PRINTING AND BOOKBINDING

122. **Photo-Engraving.**—Nearly all printing plates for the reproduction of pictures or line drawings are made by the photo-engraver. From photographs he makes half-tones and from line drawings, etchings.

In making a half-tone from a photograph for use in printed work, it may be necessary for artists to further prepare the photograph by retouching and shading different parts. In the engraving plant, a photographer then makes a negative of this prepared photograph, first placing a glass screen, ruled with cross lines, just in front of the negative plate. The screen breaks the picture into a great number of fine dots or points. This plate when developed, goes to a **stripper** who soaks it in acid to loosen the thin film containing the picture. He removes this film from the plate, turns it over and places it upon another glass plate. Then the plate is ready for the **etcher.** The etcher covers a smooth plate of copper or zinc with a sensitized preparation, places the negative plate on it, and exposes it to light to print the picture on the metal plate, just as a kodak picture is printed from a film negative. When the metal plate is washed, the printed parts remain covered and the parts which did not print are exposed as the coating is washed off. The entire plate, except the parts of the face that did not print, are protected with another coating. The etcher then places the plate in an acid bath and the unprotected parts are eaten away by the acid so that the parts desired to print stand out. A **finisher** outlines the plate, then a **router** with a machine finishes cutting away most of the surplus metal and returns the plate to the finisher. The latter removes spots and tools away any parts which the router could not remove with his machine. The engraving is usually tacked upon a wooden base by a **blocker,** proofs are made by the **prover,** and then it is ready either for the printer or the electrotyper.

Etchings are made in the same general way, except no screen is used in making a negative of the drawing and different solutions are used in the process.

Each workman in an engraving plant is a specialist in his particular work. Wages range from $25 per week up.

123. **Electrotyping.**—In electrotyping, reproductions are made from the original type forms, or engravings, (etchings or half-tones) or both, in single sheets of metal. Thus the pages of this book were printed from electrotypes, each page being one solid piece of metal,

called a **plate.** The pages might have been printed directly from type and engravings, if only a few copies had been desired, but a large number of copies printed from type would wear out the metal and the copy would have to be reset for the next printing. Also, it is more convenient to preserve plate forms than type forms. When **plates** are made, the type may be torn down and distributed as soon as the plates are finished, if it was hand-set, or recast, if it was machine-set. The plates can be retained ready to print additional copies.

Fig. 130.—Cutting down wax mould.

In making electrotypes, any number may be made from one original. The electrotyper prepares plates, usually of wax or lead, and impresses the page of type or engraving, or both combined, in the prepared plate. A heavy moulding machine is required for forcing the type material into the wax or lead plate. To make the wax impression requires skill, and, unless it is carefully done, the electrotype cannot be good. After the plate of wax is covered with powdered graphite, it is hung in a tank containing a solution and copper anodes. An electric current is passed through the tank and it causes the copper to be deposited on the graphite. The copper deposited becomes an exact duplicate of the type originally forced into the wax. Sometimes nickel is used instead of copper and the plate is called a nickeltype.

The wax is removed from the thin plate and the plates thoroughly cleaned. The plates are then placed upside down in pans by the **backers** and heated. Flux and solder are applied and, at the same time, hot lead is poured in to back-up the plates to the required thickness.

As in photo-engraving, the router and finishers prepare the plate faces for printing. If the plates are to be used on patent bases, the metal backing is planed to a certain thickness with bevel edges and the plates are ready for use. The **blocker** may tack the plates on wooden blocks, if metal backed plates are not required.

The work of the foreman, moulders, finishers, casters, routers and builders requires skill. The minimum wage in an electrotype foundry

is about $25 per week. A person entering the trade would pass, usually, from apprentice to case filler and then to one of the higher paid positions in which he showed ability.

Making reproductions of type forms for newspaper work follows a method similar to that described, but different materials and processes are used and the work is called stereotyping.

124. Composition.—Composition is the process of setting reading matter in type form. Up until the last half-century all composition was done by hand compositors. Today in addition to composition by hand, it is done on the linotype, monotype and other machines similar to these two. The linotype casts the characters on a slug in one piece of any desired length up to 30 picas. One of the latest machine methods is monotype composition, which is an exact duplication of hand work, and, instead of producing a slug, casts each letter individually. While straight reading matter is usually set on the machine, all display matter and assembling is done by hand.

Fig. 131.—Showing hand compositors and stone men.

Monotype compensation requires two machines. One machine, a "composer," operated by a keyboard makes perforations in a flexible ribbon. This ribbon is transferred to the other machine, known as the "caster." The perforations in the ribbon determine the type cast by this machine.

Fig. 132.—Linotype composing machines

A machine operator must understand his machine which is complicated, and his work requires considerable skill. It takes practice and dexterity to become an efficient operator.

Hand composition consists of picking each letter out of a case and placing it in word formation.

A person entering the work is

first required to learn the case. After a few months at that work, if he has ability, he will learn to distinguish the various faces of type, of which there are a great many in the modern printing office. At the end of the year he should be able to set small jobs by hand successfully. Practice is the thing required above all else to make speed in this work. The average shop requires about five years' apprenticeship, during which time the boy would have to do a great deal of studious work to become a proficient compositor.

Fig. 133.—Monotype composing machines.

A good common-school education is essential for this work, and a high-school education is desirable, if it can be obtained before entering the work.

The hours are eight per day, and, on an average, the wages are about $25.00 per week. The work is not heavy, but requires close application. Good eyesight and ability to group new ideas quickly are essential.

In normal times, this trade is considered to be preferable to many other trades. The good compositor can always obtain work and, as the work is in-doors, he can work practically all the time.

The really successful compositor is one who takes an interest in the various advertising campaigns, who reads the trade magazines and keeps in touch with new ideas; all of which go to help make his working conditions more pleasant and profitable.

125. **Printing Pressmen.**—The **pressman** has charge of the operation of as many as two cylinder presses and three job presses. His chief duty is in looking after the placing of forms on the presses. He takes the type after it is locked in a form or steel chase by the make-ready or stone men and has it placed on the printing press. This may be either a job press, a cylinder press, or a rotary press. The job press is called a platen press and is used for small work, as letter-

Fig. 134.—Modern printing presses.

heads and business forms. The cylinder press is for large stock which cannot be handled rapidly by hand. The rotary press is used in most of the large newspaper offices. As soon as a plate is on the press, the rollers are inked and a few sheets of paper run through. These are called the **first impressions** and from them the pressman determines whether or not the ink distribution is even, and whether there are any light or dark spots in the copy. From this he completes the **make-ready** work. This requires skill to reduce the height of the forms in places and elevate other places, so that type, etchings and halftones, all print with the proper degree of color.

Fig. 135.—Rotary printing press.

After the make-ready is finished and the impression is even and uniform, the press is started and the job run. The running of the job is done by press feeders, under the direction of the pressman. Usually it requires at least three years' apprenticeship to become a good pressman. The skill necessary can only be acquired by constant practice, and this can best be gained in the shop or vocational school. A pressman always has work and gets, on an average, about $35 per week. The work is light, and not dangerous for the young man, and this position furnishes a good opportunity.

A person entering the work would at first be placed on a platen job press as a **feeder.** This work requires skill, dexterity, and speed in placing the sheets down to the gauge carefully and accurately, and removing them as rapidly as the press prints them. There is some danger here of injury in getting the hands in the machine, although few accidents are reported from this source. Besides having the general care and supervision of his press, the platen pressmen should know how to make **underlays** or **overlays,** so that all of the impression is uniform. The ink for each job must be carefully selected and regulated. Color work especially, requires considerable knowledge and experience.

After six months or more, the beginner gradually works into the cylinder press room. The cylinder press works on somewhat the same principle, except that the sheet to be printed is fed into the machine, gripped on the cylinder and carried by it against the

form, which is on the bed plate and moves under the cylinder for each impression. This form, which contains the type, is inked by a roller between each impression when the bed plate returns from under the cylinder. The sheets of paper are deposited at the opposite side of the press from which they are fed into it, and are ready to be carried away and folded for use. The press feeder must clean, wash, and oil his machine and keep it in good shape. From being a cylinder press feeder, the good workman may become a **floorman,** in which capacity he may serve for four years before finally becoming a pressman. As a press feeder on a job press, he gets on an average of $13 per week, and on a cylinder press $19 per week. His only qualifications must be manual skill and speed. As soon as shop methods are mastered, and when he knows how to prepare a make-ready, he is eligible to the position of pressman.

The duties of the newspaper pressman differ materially from those of the job or cylinder pressman. The huge complicated rotary presses require thorough mechanical knowledge, and it takes several men, working under the supervision of the pressman, to keep one clean, oiled, and in shape.

126. **Bookbinding.**—That portion of the printing establishment where books are bound is known as the bindery. It employs a number of people, both skilled and unskilled. The bindery usually employs a considerable number of women. Bindery workers include a foreman, rulers, finishers, forwarders, cutters, folders, stitchers, gatherers, and sewers.

Fig. 136.—Folding machines.

The average printing shop does no binding, but sends its work to a bindery which operates as a separate business. On the other hand, the large firms that turn out enough work to keep a bindery force busy have a bindery in connection with the printing plant.

The beginner in the trade usually starts on such work as folding or pasting and gradually works up to the better paid positions, such as gathering and forwarding.

When the printed sheets have been folded, they are ready to be assembled. The folded sheets are gathered into what is called a

section. Except in large establishments, folding is usually done by hand. The gatherer picks up signatures in their proper order until a complete book has been assembled. A girl usually does this work and it requires but little experience.

Fig. 137.—Automatic gathering machines and wire stitchers.

Next, the assembled book or booklet is stitched. This is usually done by machinery, wire being employed in stitching small booklets and thread for sewing thick books. Wire stitching machines may stitch a booklet either in the back or side as preferred. Wire stitching machine operators are fairly well paid and the work is usually done by women.

Heavy books are sewed as wire cannot be forced through them. Also books wire-stitched from the side have the disadvantage of not opening out flat. Machines are used for sewing books in most binderies.

Forwarding includes all the operations in binding a book from the time the sewing is done until it is completed. This includes smashing, trimming, rounding, inserting, gluing on end sheet, crash, paper, lining, and head band, also backing-in and casing-in. Trimming is done by power cutters, usually operated by men. Their operation requires but little training. So with each of the many operations in the bindery. The person doing each operation becomes skilled in doing that one thing and can turn out an extremely large amount of work. These operations are both hand and machine processes and there is little chance for advancement, beyond that of obtaining good wages for dexterity and a high quality of work. The work is not heavy nor unhealthful. The foreman, of course, has the best and highest paid position of any of the workmen.

Fig. 138.—Covering machines and trimmers.

Probably next in importance come the rulers, then the finishers and forwarders. As the work depends upon so many conditions, there is considerable unemployment. There is little apprentice work in the bindery as most promotions come with increased experience without following any definite line of training.

CLAY, GLASS, AND STONE WORKING

127. Brick and Tile Making.—By the aid of machinery, brick makers produce about 1,000 brick for each eight hours of labor. The production of this 1,000 brick requires the consumption of about a ton of coal. The fuel used is worth more than the clay. There are yards which make over a million brick per day. Brick are made of clay which is used in its natural state with no other ingredients, except water, added to it. Clay known as **shale** is largely used. In the largest works, the clay is scooped into cars by means of steam shovels. It is first taken to a grinding machine called a "dry-pan." After being pulverized, the material is screened to remove all coarse materials. The portion which remains is almost as fine as flour. This is carried to a **"pug-mill,"** which mixes the clay with water to the proper consistency and leaves it wet enough for molding. The man in charge of this machine, the **pug-mill man,** must know clays, he must know when the material is properly mixed, as well as how to operate the machine. He receives fair wages. From the pug-mill, the clay is transferred to the brick machine. This machine, through an auger arrangement, forces the clay through dies. It requires great pressure to do this and the clay comes through this die in a continuous column of clay as wide as the brick is long and as thick as the finished brick is wide. This column of clay passes to an automatic cutting table where it is cut into brick by wire cutters. The man who operates the cutting table must be a mechanic. He must be constantly on the watch to see that the brick are properly cut and his chief task is to replace broken wire in the cutting frame, as wires break every few minutes.

Fig. 139.—A brick and tile plant.

The green cut brick are taken from the conveyer which removes them from the cutting table and are placed on cars, usually about 500 to the car. The cars of brick are pushed to the dry house and

left to dry for about twenty-four hours. Most concerns use artificial heat for drying. The cars of brick are next taken to the kilns, ready for burning. Shaping and burning are almost unrelated trades as the work and processes are entirely different. Brick are burned from 7 to 10 days of continuous firing, the heat being gradually increased until during the last two days they are in white heat, or about 2,000° Fahrenheit. After burning, it requires about five days for the brick to cool and temper. Paving brick and fire brick are burned at a still higher temperature than building brick. The temperature and time of burning depend in part upon the nature of the clay. Fire brick are made from clay that is free from iron. The common building and paving brick obtain their red color from the iron present in the clay.

The **burner** is quite a skilled man. He must know the properties of different clays, how fast they will stand firing, whether they are checking, burning down, etc., in the kiln, and the required kiln temperature for best results. His ability is obtained almost entirely by experience, as clays vary remarkably in their properties to burn properly. As burning goes on continuously when once started, both a night and day burner are necessary. Burners receive good wages.

Hollow tile are made by the same processes, except the tile molding machine produces a round hollow column of clay instead of a solid rectangular one. This column is then cut to proper tile lengths. Burning tile does not require as much time as for brick, since they are not so thick. Curved roofing tile, ornamental tile, etc., are formed by shaping a thin strip of the clay over a mold. This work is done either by hand or by machine. The beautifully glazed tiles used for hearths and bathroom floors, are partly burned, taken out and dipped in glazing material, and burned again. Large drain tile are molded by special machines.

A general mechanic is needed in a brick or tile factory to repair the various machines, as motors, pug-mill, cutting table, and off-bearing system. Most of the labor in a brick or tile factory is unskilled and, in general, the wages paid are low. While the work is heavy, it is not unhealthful, nor dangerous.

128. **Glass Working.**—The glass industry received its greatest forward movement with the advent of glass-blowing machines, at the beginning of the twentieth century. Previously, glass-blowers did all the blowing and were highly paid laborers.

With the introduction of glass blowing machinery, the work was made easier and more could be produced per man. Most window

glass is still blown by glass blowers. In general, a more intelligent class of men are employed for the work than formerly. The chief occupations in the glass industry are those of blowers, cutters, flatteners, gaffers, gatherers, leersmen, packers, and teasers.

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Fig. 140.—Placing material in furnace. Plate glass factory in Ohio.

There are distinct classes of glass workers; flat glass workers, as window makers; hollow glass workers, as bottle blowers; colored glass workers, and cutting and decorating glass workers. Flat glass workers include the men engaged in making "blown" window glass and plate glass.

The men in a glass factory first mix a "batch," and place it in a tank in a furnace where it is melted. The molten glass is passed to another tank called a refining tank, and finally into a third tank from which it is taken as needed. Around these fiery tanks containing from twenty to thirty thousand cubic feet of molten glass with their glowing openings, intense heat, gas laden air, and poorly lighted space, are many lightly clad men and boys. Some are running back and forth, carrying hot blown glass, others are swinging balls of glowing metal on the end of long pipes and, amid the clanking of machines and roar of the glowing furnaces, present a very strange and wonderful sight. This work looks more dangerous than it is, but such a scene cannot fail to impress one with the fact that much of the work is very unpleasant. Good wages is the best thing that can be said in favor of the work.

Glass workers use three chief methods in making glassware: blowing, casting and pressing. A glass blower uses an iron blow pipe about 6 feet long. From the tank, a pasty red hot ball of glass is gathered on the end of the blow pipe. Swinging this ball of molten glass backward and forward, he blows it into a cylinder of glass five or six feet long and a foot or more across, much as a soap bubble is blown.

The glass blower's work is strenuous and it requires a strong man to handle the heavy mass of glass. He receives excellent wages.

Usually he has a **gatherer** to help him who gathers the molten glass on the blow pipe, from the tank. The blower turns the cylinder of glass over to another worker who cuts off the rough ends and splits it lengthwise. The cylinder is still hot enough to be slightly plastic and, when split, flattens out. Other workers place the flattened sheet of glass in an annealing furnace where a man called a **flattener** smooths it true and level.

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Fig. 141.—Plate glass on grinding table.

The sheets of glass are then cut to size for windows, doors, etc., by **glass cutters.** They become very skillful and are able to cut glass with speed and accuracy. Usually, they work piecework and their wages are excellent. An expert glass cutter can make as good wages as any workman in the industry.

Plate glass workers pour molten glass on a large flat table. A roller presses the molten glass to the desired thickness, after which it is removed to the annealing furnace and slowly cooled. Next **grinders** using power machines grind the thick pieces smooth, polish them, and bevel the edges. Plate glass workers receive good pay but part of their work is very dangerous.

Glass blowers also blow bottles, tumblers, fruit jars, etc., using "press" and "blow molds." A gatherer passes a pipe containing molten glass on the end of it to a blower who places it in a mold, and blows it to the shape of the mold. A boy called a "mold tender" usually opens and closes the mold and passes the bottle to another boy who carries it to the annealing furnace. More recently, glass blowing machines blow the bottles better and quicker than can be done by blowers. A gatherer with a solid rod or "punty" takes enough glass from the furnace to make a bottle and drops it into the press mold. Another man closes the mold, which presses the neck of the bottle to shape and makes a hollow through the neck to start the blowing. The press mold is removed and the partly formed bottle is placed in a blow mold. By compressed air, the bottle is then blown to shape. Practically all bottles, fruit jars, etc., are now blown by machinery.

Other glass workers take plain heavy glass vessels called "blanks" and by means of rapidly revolving grinding wheels cut beautiful designs in the glass, producing "cut glass." The cutter in time becomes expert and, as he usually does piece work, a skillful man receives high wages. Special workers shape and make glass into many beautiful and useful things, as spun glass, glass beads, mirrors, thermometers, light bulbs, optical glasses, microscopes, and vases.

Many of the positions in glass factories are filled by foreigners and, while most of the positions offer good pay, the working conditions, dangers, and unhealthfulness make the work unpleasant. A bright boy who is willing to study the processes and work hard can go far in this industry as such persons are needed to supervise the many unskilled workers. One of the greatest objections to the glass worker's trade is the fact that during the warm months of the year the factories are usually closed.

129. Stone Working.—The working of stone is a very old trade. From primitive methods of forming stone tools and weapons, it is quite a step to the modern cutting of stone for use in buildings, paving, road building, monument work, and interior decoration. Stone is now prepared for its many uses by the aid of machinery. Where stone is being worked, power saws cut the stone into blocks, or slabs. The pieces are thus cut to exact size and shape. Men who work on the stone, cutting, polishing and turning it, do very heavy and hard work at a comparatively low wage. Pneumatic hammers cut off undesirable corners, or edges, and pneumatic drills make holes or cut out designs in the stone. The men who operate these tools become skilled in their manipulation and in judging the quality and nature of the stone. They receive fair wages. Ornamental stone faces are polished with abrasives, the work being done by machinery. The polishing requires little attention after the work is started, but the machine operator needs to be experienced. The skill of the men employed largely determines the appearance of the finished work.

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Fig. 142.—Chiseling marble in Vermont.

Edges are squared on a rubbing bed, which revolves at a high rate of speed and, with sand and water as an abrasive, soon trues up the edge or surface. Carborundum is now widely used as a grinding or cutting medium. Stones can be rapidly trued to exact size and shape by the aid of carborundum wheels.

Stone cutters carve out designs by means of pneumatic hammers which are able to strike as many as 3,000 blows a minute. Large columns are turned out on lathes just as wood is turned. For fine carving, hand work is necessary and the work requires the highest skilled men in the stone cutting trades. However, the number of men required for this work is relatively small and in the stone working industry unskilled labor predominates.

Most of the skilled men are mechanics who are skilled in the manipulation of machines and are able to utilize the power of machines in working, lettering, setting, polishing, and fixing stone.

130. Pottery.—Pottery making includes that branch of manufacturing which has to do with the forming of earthenware, both glazed and unglazed. Pottery made of clay and burned without much care or attention to beauty and finish is usually called **earthenware.** Pottery that is glazed, yet not of the finest materials, is classed as **stoneware.** The finest grades of pottery are designated by the term, **porcelain.** The china-ware used on the table belongs to this class.

Pottery varies widely in composition, although all grades and kinds are made chiefly from clay. But clay varies in its composition and it requires much skill on the part of the potter to know how to handle the different mixtures. Feldspar, flint, borax, and silicon are also used in this work. When a good and workable clay has been located, the earth above it is removed and a considerable portion of the clay exposed. A stream of water is passed over the bed of clay and, at the same time, men are busily engaged in breaking down the lumps and stirring the clay so that the stream of water becomes saturated with the fine particles. The water carrying the clay is collected and the clay allowed to settle, forming a

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Fig. 143.—Shaping plates on potter's wheel.

thick, creamy liquid at the bottom of the settling pit. This purified clay is removed to huge tanks and water gradually taken out until that which remains becomes a pasty mass, and the proportion of clay and water is about half and half. Then, the clay is finally dried either by heating or by filtering. At the pottery this washed and dried clay is placed in bins ready for the actual work of the potter.

A laborer weighs out the proper proportions of each material as clay, flint, and silica required for the objects to be made, then shovels the mass into a machine called a "blunger," which is a tub about 10 feet in diameter and 6 feet deep. Revolving arms in this tub mix the materials with water so that in about 2 hours a cream-like mixture of fluid clay is obtained. This is screened, to remove the coarser particles, and filtered to obtain the moist, fine clay. This clay is put through the "pug-mill," which further mixes it and removes air that is mixed with it. Formerly this work, called wedging, was done by hand after the fashion that bread is kneaded. Finally, the clay is ready for shaping. It may be shaped by hand, pressed to shape by machine presses, or molded much after the fashion that metals are molded. The molder in the pottery works first shapes the object or, if it is a complicated article, he shapes one part of it. Other molders shape other parts and the parts are passed to another man who smoothes the uneven surfaces and edges. Parts are next assembled, and the parts, as handles and spouts, are stuck in place by means of moist clay. The green molded objects are placed in large containers, called "saggers" and these saggers are stacked in a kiln for burning. The kiln is gradually brought to a temperature above 2000° Fahrenheit, and, after burning, it is slowly cooled. This burned material is unglazed and is now ready for decorating and glazing. Decorations are put on by hand or transferred by paper patterns. The objects are then dipped into a glazing preparation, consisting chiefly of the finely ground materials used in making glass. The articles, after being dipped, are burned again in a "glost kiln," at a lower temperature than before and are finally removed, inspected, and packed for market.

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Fig. 144.—A model shop in pottery works in New Jersey.

Casting is another method used in making such vessels as pitchers, jars and similar articles. A mold hollowed out to the shape of the object is constructed. The mold is filled with liquid clay. After standing a short time, the clay adheres to the surface of the mold forming a thin shell. Then the remainder of the clay is poured out. After a time the thin shell dries and shrinks away from the mold when it may be removed and the article put through the processes of burning, decorating and glazing as described for molded articles.

Molding, casting, pressing, joining, decorating, etc., require hand work, and the persons engaged in these tasks become skillful. They receive good wages and, as their training is gained almost entirely by experience, they have to serve no definite apprenticeship. There is not, however, much chance for advancement.

The firing of pottery requires the services of well trained men to supervise the work. New devices for controlling temperature have greatly improved the burning work. The work is not unhealthful, but the largest portion of the workers are unskilled.

MISCELLANEOUS OCCUPATIONS

131. **Leather Working.**—Not so many years ago the hide of an animal had but little market value and only those hides that could be quickly gotten to the tannery were salable. With the rapid growth of the leather industry, the skins of many animals formerly considered valueless were utilized. The sheep, hog, calf, pig, goat, horse, chamois, as well as the rhinoceros, and the alligator, all contribute to the millions of dollars worth of leather products manufactured in the United States each year. Not only does the United States use all domestic hides produced, but annually expends large sums for imported hides. The imported cattle hides, calf skins, goat skins, and sheep skins for 1914 amounted to more than one hundred million dollars. Skilled workmen assisted by marvelous power machines convert these hides together with those produced here into a wide range of articles. The products consuming most of the leather are, shoes, harness and belting, upholstering, traveling cases, and novelty goods.

Shoes.—In the modern shoe factory, there are six general divisions of the work each with its superintendent and foremen. These divisions are: the upper leather department, the stitching

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Fig. 145.—Lasting machines shaping shoes in a Massachusetts factory.

department, sole leather department, making department, finishing department, treeing, packing and shipping department. These divisions are carried much further in the larger factories. For example, the upper leather department may be divided into the sorting, trimming and cutting, lining, upper cutting, counting and marking, and assembling departments.

In the **upper leather** department, the leather is cut to shape, skived and marked for the entire shoe with the exception of the sole. Also lining material is cut to shape. Most of the work in this department is done by machines. The machines which cut the patterns are called "clickers." Formerly the term applied to persons who cut out the leather by hand. Leather sorters who supply from the stock room the leather as required for each order are specialists. They must be able to judge exactly the amount and quality of leather needed to cut each order. They usually serve several years apprenticeship as cutters so as to become familiar with the value of leather. Lining sorters render a like service in selecting lining material. This work requires experience in textiles. Cutting the cloth and leather employs both hand and machine cutters, besides inspectors and foremen. Cutters need to be experienced to prevent wasting leather, as the ability of the cutter determines, in part, how many patterns can be cut from a piece of leather. Many of the positions in the upper leather department are held by girls. The work requires both speed and dexterity, but each person can soon become a specialist as the work is confined to a few operations usually performed on a machine.

The stitching department uses about two-fifths of all the labor in the industry and most of the workers are women. The work is done almost entirely by automatic machines, and the girls tending the machines become very skillful in feeding and manipulating them. In general, the wages are low.

The sole department uses men for most of the work. It does not require so many operatives as the stitching department.

The **making department** is also called the gang room. In this department many machine operations are carried out and, while skill is required in operating the machines, the positions are not the most desirable.

The finishing, treeing, packing and shipping are carried on by persons usually not highly skilled. The inspectors, however, must be experienced and highly trained workers.

The leather industry has many highly specialized divisions, some of them requiring a long period of apprenticeship. Skilled laborers are always in demand, and they may expect promotion from time to time. The work on most of the machines is very monotonous, and wearing upon the operators. As the larger part of the work is done on a piece-work basis, the premium on speed tends also to be injurious to the workers.

Belting and harness are made chiefly from leather, machines being used for most of the work. The hides after inspection go through machines for slitting, gluing, pressing, and shaping the material. The processes of punching, riveting, sewing and joining require men skilled in the performance of each operation.

Leather upholstering is very popular, serviceable and beautiful. While many substitutes have recently appeared for this purpose, leather still holds an important place in the upholstering industry. Practically all the work of upholstering is done by hand. The leather used is inspected, sorted and then cut to shape, by hand. The processes of sewing, tacking and glying the leather in place are also done by hand. Upholsterers become expert workmen.

In making traveling cases and novelty goods, hand processes are used more than in highly specialized industries, as shoe making. Cutting, stitching, shaping and decorating processes are modified in making various articles, but, in general, are the same throughout the industry. Machine operators need to be able to do more than merely operate one machine and in time become expert leather workers. The manufacturers of leather goods are rapidly introducing machines wherever operations can be standardized, and most leather workers are now required to have mechanical ability. Promotion in the industry comes almost entirely through successful workmanship in the shop, no amount of education being able to make up for a lack of experience. Of course, a good school education is an advantage in obtaining more rapid promotion. For the higher positions, a good education is essential.

132. **Rubber Goods.**—The manufacture of rubber goods is one of the few great industries which has grown to an undreamed of immensity and importance in a few years. For example, the yearly output of automobile tires is approximately 18,000,000, with a value exceeding $450,000,000. The future of the rubber industry judged by the past is so great that it should offer a strong inducement to the young man selecting a trade. The workers in the factories producing rubber goods may be divided into many classes, but they produce, in general, either soft rubber goods or hard rubber goods, called "ebonite." In making either class of goods, the preliminary processes of washing, drying, grinding and mixing are similar.

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Fig. 146.—Rubber tire making.

Crude rubber (See Art. 233, Sec. 2) is first washed by men who place the large chunks or "biscuits," in tanks of hot water to soften. Next, they roll the rubber into thin sheets, washing it constantly as it passes through the machine rollers. It leaves the washers as clean, thin, porous sheets of rubber. The men who next dry the rubber must be careful to keep the correct temperature, and to remove the rubber at the proper stage in the drying process.

Mixing consists of incorporating with the rubber the necessary quantity of sulphur and filling materials. Chemists determine the exact amounts to be used for each "batch" of the pure rubber, to make the desired articles. Probably no one plays a more important part in the work than the chemist. (See Art. 134.) Men grind the sheets of rubber and mix in the materials by means of machines which work requires no particular skill.

To be able to use this mass, it must be "calendered." A pair of heavy steam heated rolls squeeze the mixture into long sheets, and leave it ready to be cut to shape.

Soft rubber goods made from this prepared mixture of rubber, sulphur and fillers consist of sheet rubber goods, pressed goods, and molded goods.

The whole process is one of mixing, shaping and baking. The baking changes the material from a sticky mass into a tough, elastic article. The material added largely determines the properties of the goods made. For cheapness, whiting is used as a filler; for toughness, zinc is used; for smoothness, plumbago is used; for heat resisting properties, powdered asbestos is added; for hardness, sulphur is added, and so on. Soft rubber contains but little sulphur and is baked but a short time. The articles made from such rubber constitute most of the common soft rubber goods, as tires, belting, boots, shoes, insulation for wire, and surgeon's supplies.

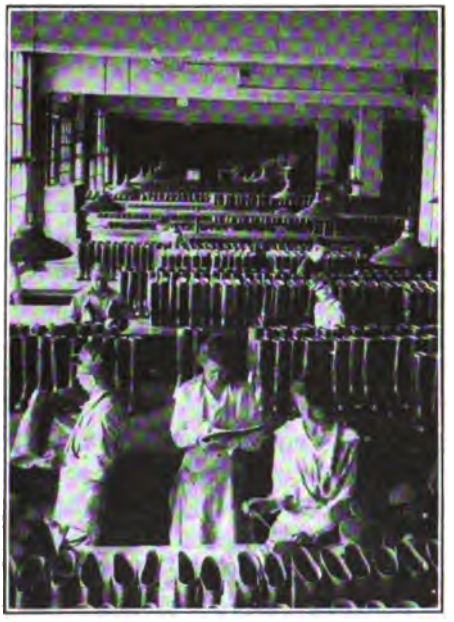

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Fig. 147.—Inspecting and checking rubber boots in an Ohio factory.

Outside of the preparation of the crude rubber, the work in each line of the many divisions of the industry is entirely different, so much so that an expert in one may know little about the other. The machinery, ovens, formulaes and processes are so varied that each of the many distinct branches requires specially trained workers.

Hard rubber goods are no different from soft rubber goods in composition, except for the large amount of sulphur used and the high temperature at which they are baked or "vulcanized."

The factories devoted to the manufacture of hard rubber goods turn out telephone receivers and mouth pieces, fountain pens, combs, and like articles. The workers in such factories must be skilled, but they will probably know nothing at all about the making of soft rubber goods.

It is this variety, this wide field of work, and great magnitude of the rubber industry that make it a highly desirable field for the young man to enter.

133. **Paper Making.**—Materials from which paper is made include rags, rope, esparto, manilla, straw, and wood. The best paper is made from rags, but by far the largest amount is made from wood fibers. Paper-makers make a wide variety of papers by blending the different materials, in different proportions and manners. To make paper as required, either strong or soft, absorbent, or resistant to grease and water, light or dense, calls for special knowledge and skill on the part of the paper-maker. To see bales of rags, tons of straw, and thousands of feet of spruce go in at one end of a mill and a day or so later come out in the form of beautiful, clean, white, or tinted sheets of paper indicates that men of skill are at work somewhere in the mill. From logs worth probably one-twentieth of a cent per pound, finished paper worth 20 cents a pound is prepared through this process. The workers who bring about this change include sorters, shredders, cookers, washers, engineers, chemists, loaders, sizers, glazers, deckel tenders, felters, driers, calenderers, graders, inspectors, folders, cutters, wrappers and packers.

Fig. 148.—Dressing rags in a paper mill.

Sorters, usually women, remove foreign matter or "dress" the rags as soon as they start through the mills. They remove such material as buttons, scraps of metal and rubber, and sort the rags according to the grade of paper being made. Their work is rather undesirable when old rags are used, but not so in handling new cuttings from shirt, collar, underwear or similar factories. The **shredders** and **cutters** operate machines which beat out much of the dirt and chop the rags into fine shreds. The **cookers** place the partially cleaned and shredded rags in huge cookers of from 5,000 to 12,000 pounds capacity and boil them under pressure in a solution of lime and soda. This loosens resinous matter, dirt and color. The **washers** wash out this loosened color and dirt and in the washing tanks the fibers are again beaten by movable arms to thoroughly separate them. The milky appearing liquid carrying the clean fibers is forced through a

fine screen which removes any coarse fibers or material. Next, this liquid is passed on to an endless belt of wire, where part of the water filters through, leaving a layer of the fibers on the screen. The screen passes this layer of fibers through rollers which are heated by steam. These rollers press, felt, dry, and smooth the fibers into true paper.

Fig. 149.—Paper making machines. The "wet end" of the route the material travels.

The men engaged in treating paper to produce a special body, color or finish add chemicals at various stages in the manufacture and pass the paper through different vats and machines, to obtain desired results.

Finally, sorters remove imperfect sheets and inspectors examine and test the finished paper for strength and defects of all kinds. When passed by the inspectors, the paper goes to the packers who prepare it for shipment.

In paper-making, part of the labor is unskilled, and some of the work unhealthful. However, chemists regulate the processes, skilled hands supervise the work, and experienced workmen operate the many machines.

134. Chemical Products.—Probably no industry depends so largely upon the ability and skill of the workers as does the field of chemistry. Following tirelessly along new lines, often lead by the most slender thread of hope, chemists have produced many indispensable products. From using chemicals for only a few purposes, within the last few generations man has come to depend upon chemical products to correct bodily ailment, to dull pain, for clothing, to furnish food, for decorating his home, and to do work in the preparation of things which he could not otherwise have. The production of our chemical industries has, in a few years, risen in value from almost nothing to an amount nearly equal to the value of our agricultural products. Chemical products are so many and varied and processes are so complex and different that chemists in different industries can be skilled only in their special line. Most chemists engaged in producing substances of commercial importance are called **industrial chemists.** The industrial chemist may be a food chemist, an assaying or analytical chemist, he may be a specialist in biochemistry, organic, metallurgi-

cal, geological, pharmaceutical or synthetic chemistry, or he may know the chemistry of sanitation, of making fuels, fats and oils, explosives, dyestuffs, glass, glue, adhesives, leather, varnish, paint, and in fact, an almost endless list of modern products.

The industrial chemist uses those manufacturing processes involving the combination or separation of compounds, combines substances in various proportions to produce commodities with new properties, installs apparatus for carrying on such operations, and examines analytically the quality of the output. He is needed in the steel mill, the oil refineries, the smelters and the munition works, and the results of his efforts furnish the foundation of many other industries. For example, pottery works, paper mills, factories manufacturing rubber products, dyes or fertilizers, employ chemical principles and process which must be supervised by the industrial chemist.

The field of the industrial chemist is unlimited. No one can predict how marvelous the future results of these workers will be. It is so broad that any one who likes chemistry can find a phase of the work suited to his taste. The opportunities are more numerous than the workmen and no difficulty is experienced in gaining a position.

Besides chemists, these manufacturing plants employ assistant chemists and thousands of other men who, although they are not chemists, are thoroughly familiar with and expert in manipulating or bringing about one or two chemical changes. These men receive better than unskilled pay, and while, in some industries, their work is unhealthful, in most places it is light and pleasant and offers opportunities for advancement. Establishments making chemical products also employ many unskilled workers. These unskilled workers are supervised by the chemist and his assistants, who see that the processes are faithfully followed. Thus in the mines, it is the chemist who tells the men what to remove and what to leave. In the refinery, he tells them how to proceed and tests the result; in the steel works, he tells them what to add to the iron, the temperature required, and the methods to follow; in the dairy, he tells them when to churn, and how much butter to expect. Men who do the actual work may be very adept workers, but they are not chemists. These workers need a good general education, and the special knowledge needed in their work can then be obtained by working up to the position in the plant.

A workman without at least a good general education has little chance to rise to positions requiring more than manual dexterity, as the science of chemistry cannot be learned merely by practice.

The **pharmaceutical chemist** is interested in compounding those materials having medicinal and healing properties. He prepares compounds and solutions chiefly for application and administration to man and animals. In making pharmaceutical products, as tablets, crude products are obtained, cleaned and purified, and mixed in the proper proportions. Tablets are stamped out of this material by machines, each machine being able to turn out many thousand tablets per day. In such work, cleanliness, speed and dexterity are required of the workers and some of the more important positions as foreman, stockman, and assistant chemist, demand a working knowledge of drug terms and characteristics. Much of the work in running machines, bottling drugs, sealing, labeling, and wrapping, requires little knowledge on the part of the workman, and such work would probably never enable the workers to gain a highly desirable position.

The training of the worker entering the chemical industries should be as complete as can be obtained. A good general education is necessary, and a general course in chemistry is advisable. When the training period is completed, almost any branch of the science offers a future rich in opportunities.

SECTION TWO

MATERIALS

by

J. I. SOWERS,
Director of Vocational Education,
Vincennes, Indiana.

MATERIALS

1. Two factors are essential in the development of industry, namely, materials and tools. Materials are supplied by nature, but the science of man has determined most of their uses. The progress of civilization, with its necessary increase of human wants, invites and compels man to invent and discover means for their gratification. There is a continuous search for new methods of utilizing materials; and man, by discovery and science, is constantly adding to the list of valuable products. In this way new raw materials are being utilized and old materials are being made to yield new products. The chemist searches in the waste products of cities for things that may be remanufactured and made useful. The waste of mills, factories and mines is made over into by-products of use, beauty and value.

The materials used have become so varied and their uses so numerous, that each man, in the trades, works almost entirely with a single kind. The material used indicates the general class of workmen to which he belongs, as, carpenter, mason, lumberman, machinist, blacksmith, etc. For these reasons, the study of materials becomes necessary to the worker, and a knowledge of them is a very essential part of his mental equipment.

Substances used in industry are derived from three general sources: plants, animals and minerals. They may be used in their original state, or it may be necessary to modify and change their character. Materials produced from plants and animals are generally used with but slight modification. For instance, wood does not differ in its essential character, whether in the frame of a building or in a tree. The wool of the sheep or the fibre of the cotton plant woven into cloth differs but little in character from that of its raw state. Substances of use in the trades, produced by plants and animals, are improved by careful selection and breeding. The profitable production of plant or animal material is much influenced by the mode of its collection or removal, and by processes which separate the useless, or less valuable, from that which is valuable.

Minerals used in industry, except mineral fuels, stone and a few others, must undergo considerable modification and change in their

nature before they are adapted to special needs. While materials derived from plants and animals can be modified in their growth and development, no skill of man can alter the natural condition of ore in the mine. The composition of mineral substances is not influenced by climatic conditions or geographical locations. The profitable production of a mineral substance is determined by its geographical location, by the civilization of the people to whom it is accessible, by the modes and facilities of transportation, and the methods of refining.

The important mineral, plant, and animal substances, the processes by which they are prepared for use, and the resulting products are considered in this section, for the purpose of giving trade information.

Structural Materials

WOOD

2. Man requires food, shelter and heat. Wood is one of the chief materials utilized to satisfy these wants. The ease with which this material responds to labor, and the wide range of uses to which it is suited, place it first in value among the raw products.

As this book is designed for persons who handle wood as a product used in manufacture, that is as a dead material, consideration is given only to those distinguishing properties, a knowledge of which is useful and necessary for the worker in wood. Persons who work in wood should learn to recognize the common kinds of wood without the aid of information which observation of the standing tree affords.

Physical Properties of Wood

3. Woods vary in hardness, elasticity, strength, weight, resistance to weather, beauty of markings and color, toughness and shrinkage. These properties enter into consideration in the selection of the kind of wood to be use for a particular purpose.

4. **Hardness.**—Hardness as a characteristic of wood determines its use where resistance to wear is necessary, as in turned objects, handles, carvings, shoe lasts, wooden balls, rulers, and pulleys. Hardness is also a means of distinguishing one wood from another. In the United States Forest Service, the weight required to force a steel ball .444 of an inch in diameter one-half of its diameter into wood, is the test of hardness. A table of hardness is given on page 170.

5. Elasticity.—Elasticity in wood is important, especially in the manufacture of bows, skees, gymnasium apparatus, boats, and articles where ability to spring back into shape is desirable. The elasticity of wood fiber increases its strength and resistance to strain. This quality is found in the following common woods in the order named: larch, birch, longleaf pine, maple, shellbark hickory, spruce.

6. Strength.—Strength is a property of certain woods to a remarkable degree and is the most important quality of many woods. Hickory approaches closely to cast iron in strength under the same tests, and will stand greater strain than a wrought iron bar of equal dimensions. Woods are chosen for strength in wagon construction, levers, handles, framing construction, furniture, and agricultural implements. The strength of timbers is classified according to the nature of the

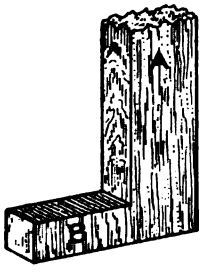


Fig 1.

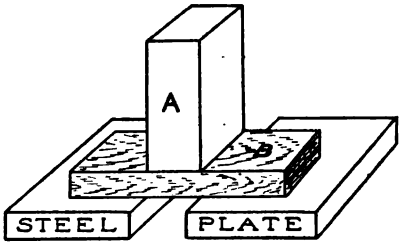


Fig. 2.

stress to be met, as, **crushing** strength, **tensile** strength, and **shearing** strength. **Crushing strength** is the resistance which wood offers to pressure exerted end to end with the grain. See table on page 171. **Tensile strength** is the opposite of crushing strength and relates to the ability of any material to hold together under a direct pull parallel to the grain. The tensile strength of wood is from two to four times greater than the crushing strength. **Shearing strength** relates to force exerted in such a way as to tend to slip the fibres of the wood, one on the other. Shearing strength may be determined either across or parallel to the grain. It is closely related to hardness when applied across grain. In Fig. 1, if force is exerted upon the upright "A" until the part "B" is broken off by downward pressure, the force necessary to do this determines the shearing strength of the piece. If the part "B" is one inch square, the sheared surface will be one square inch. The force so applied indicates the shearing strength per square inch,

parallel to the grain, of that particular kind of wood. In Fig. 2, force is exerted downward on bar "A" until the piece of wood on the steel plates begins to shear off. This is called shearing across the grain. A tenon is sometimes broken off in this manner by pressure in excess of its shearing strength.

HARDNESS OF VARIOUS WOODS

(Pressure in pounds required to indent specimen to depth of one-half diameter of a .444-inch diameter steel ball)

SOFTWOODS

Fir, Alpine	219	Pine, Norway	342
Spruce, Englemann	243	Spruce, Red	346
Cedar, Western Red	246	Cypress	354
Cedar, Northern White	266	Tamarack	375
Pine, White	296	Fir, Grand	375
Pine, Lodgepole	315	Hemlock, Eastern	406
Pine, Western Yellow	320	Douglas Fir	408
Pine, Sugar	324	Hemlock, Black	464
Fir, White	328	Pine, Longleaf	512
Pine, Table Mountain	333		

Average Hardness ---------- 340

HARDWOODS

Basswood	242	Beech	824
Buckeye, Yellow	286	Maple, Hard	882
Willow, Black	334	Elm, Rock	888
Aspen, Largetooth	366	Birch, Sweet	894
Butternut	386	Oak, Yellow	926
Cherry, Red	386	Ash, White	941
Elm, White	511	Witch Hazel	977
Cucumber	515	Oak, Red	982
Ash, Black	548	Ash, Green	1,007
Sycamore	580	Ash, Blue	1,028
Sumac	590	Oak, White	1,063
Maple, Silver	592	Oak, Post	1,074
Maple, Red	612	Oak, Bur	1,108
Elm, Slippery	653	Oak, Swamp White	1,158
Cherry, Black	664	Laurel, Mountain	1,299
Hackberry	677	Dogwood	1,408
Tupelo	700	Locust, Black	1,568
Birch, Yellow	745	Locust, Honey	1,846
Ash, Pumpkin	752	Osage Orange	2,037

Average Hardness ---------- 844

CRUSHING STRENGTH OF VARIOUS WOODS

(Pounds per Square Inch; Pressure Applied Parallel to Grain)

SOFTWOODS

Spruce, White	1,940	Fir, Grand	3,030
Spruce, Englemann	1,980	Cedar, Incense	3,030
Cedar, Northern White	1,990	Fir, Amabilis	3,040
Fir, Alpine	2,060	Pine, Table Mountain	3,070
Pine, Western Yellow	2,400	Pine, Norway	3,080
Pine, Lodgepole	2,460	Hemlock, Eastern	3,270
Pine, Sugar	2,600	Hemlock, Western	3,390
Cedar, Western Red	2,630	Tamarack	3,480
Pine, White	2,720	Pine, Shortleaf	3,570
Spruce, Red	2,760	Larch, Western	3,700
Fir, White	2,800	Cypress	3,960
Hemlock, Black	2,890	Redwood	3,990
Douglas Fir	2,920	Pine, Longleaf	4,280

Average Crushing Strength 2,960

HARDWOODS

Willow, Black	1,320	Oak, White	3,510
Buckeye, Yellow	2,050	Cherry, Black	3,540
Basswood	2,140	Tupelo	3,550
Cherry, Red	2,170	Birch, Sweet	3,560
Ash, Black	2,300	Dogwood	3,640
Butternut	2,410	Elm, Rock	3,740
Maple, Silver	2,490	Maple, Hard	3,850
Hackberry	2,520	Hickory, Big Shellbark	3,890
Sumac	2,680	Hickory, Nutmeg	3,980
Gum, Red	2,690	Ash, Blue	4,180
Aspen, Largetooth	2,720	Ash, White	4,300
Sycamore	2,790	Laurel, Mountain	4,310
Elm, White	2,810	Oak, Swamp White	4,360
Cucumber	3,140	Ash, Green	4,360
Elm, Slippery	3,180	Hickory, Bitternut	4,570
Beech	3,280	Hickory, Shagbark	4,600
Oak, Bur	3,280	Hickory, Water	4,660
Oak, Post	3,330	Hickory, Mockernut	4,720
Ash, Pumpkin	3,360	Hickory, Pignut	4,820
Oak, Red	3,370	Oak, Tanbark	4,840
Oak, Yellow	3,390	Locust, Honey	4,970
Maple, Red	3,390	Osage Orange	5,810
Witch Hazel	3,400	Locust, Black	6,800
Birch, Yellow	3,460		

Average Crushing Strength 3,580

SPECIFIC GRAVITY OF VARIOUS WOODS

(Test pieces "oven-dry")

SOFTWOODS

Cedar, Northern White	.29	Fir, Amabilis	.38
Cedar, Western Red	.29	Hemlock, Eastern	.38
Spruce, Englemann	.31	Spruce, Red	.38
Fir, Alpine	.31	Pine, Table Mountain	.39
Spruce, White	.32	Douglas Fir	.42
Redwood	.35	Hemlock, Black	.42
Fir, White	.35	Hemlock, Western	.42
Pine, Sugar	.36	Pine, Norway	.44
Pine, White	.36	Cypress	.45
Cedar, Incense	.36	Larch, Western	.46
Pine, Western Yellow	.37	Pine, Shortleaf	.48
Pine, Lodgepole	.37	Tamarack	.49
Fir, Grand	.38	Pine, Longleaf	.53

Average Specific Gravity of Softwoods .39

HARDWOODS

Buckeye, Yellow	.33	Hickory, Nutmeg	.56
Willow, Black	.33	Witch Hazel	.56
Basswood	.34	Maple, Hard	.56
Aspen, Largetooth	.35	Oak, Tanbark	.56
Butternut	.36	Oak, Yellow	.56
Cherry, Red	.36	Oak, Red	.57
Elm, White	.43	Elm, Rock	.58
Gum, Red	.43	Oak, Bur	.58
Maple, Silver	.44	Birch, Sweet	.59
Cucumber	.44	Oak, Post	.59
Sumac	.45	Oak, White	.60
Sycamore	.45	Laurel, Mountain	.62
Ash, Black	.47	Hickory, Bitternut	.62
Cherry, Black	.47	Hickory, Water	.63
Elm, Slippery	.47	Hickory, Shagbark	.63
Tupelo	.48	Hickory, Big Shellbark	.63
Hackberry	.48	Oak, Swamp White	.64
Ash, Pumpkin	.49	Dogwood	64
Maple, Red	.49	Hickory, Mockernut	.65
Ash, Blue	.53	Hickory, Pignut	.66
Ash, Green	.53	Locust, Black	.66
Beech	.54	Locust, Honey	.70
Ash, White	.55	Osage Orange	.76
Birch, Yellow	.55		

Average Specific Gravity of Hardwoods..... .53

7. Weight.—Weight is a property of wood closely related to strength, for the reason that weight and strength each depend upon the number and compactness of wood fibers. Weight, in part, determines the use of wood. A mallet head needs much weight and small volume; other articles, as tent poles and ladders, need to be light and strong. Weight also helps to identify woods. It is one of the quickest means of detecting an imitation where a cheaper wood has been made to resemble another and more valuable wood. If a very thin cross section of wood is dropped into water, it sinks, showing that the substance of the wood fiber is heavier than water. The weight of wood is usually expressed by comparing the weight of a given volume with an equal volume of water. This is known as "specific gravity." If the specific gravity of a certain kind of wood is given as .30, this means that a given volume of this wood weighs 30 times as much as an equal volume of water. A cubic foot of water weighs 62.5 pounds; a cubic foot of wood of specific gravity .30, weighs .30x62.5, or 18.75 pounds.

It has been determined that wood substance is approximately 1.6 times as heavy as water. This is true of all kinds of wood, basswood as well as ebony. The reason a given volume of one wood has a different specific gravity from another is because there are more air spaces in the lighter wood, and not because the wood substance itself

is any different in weight. Wood of any size or kind will float only until its cells become thoroughly filled with water.

The weight of any kind of wood varies, depending upon the amount of water contained in the wood cells; or in other words, how thoroughly the wood is "seasoned." The table on page 171 gives the specific gravity of common woods when seasoned, or oven-dry.

8. **Beauty of Markings and Color.**—Beauty of markings and color are important considerations in the selection of wood for cabinet work or interior finish. Some woods are of a decided color. Ebony is black, while holly and basswood are almost white. Black walnut is one of the darkest of our native woods. Sweet gum is of a reddish brown color, often beautifully grained, and has recently become of importance as a cabinet wood, especially in veneer work. It is also used in imitation of black and circassian walnut. Oak, when quarter-sawed, presents a desirable effect in its markings, due to the medullary rays. Any wood in which the medullary rays are pronounced, will show a beautiful grain when cut on a radial section. Birch, beech, tulip, sycamore, cheery and maple are examples.

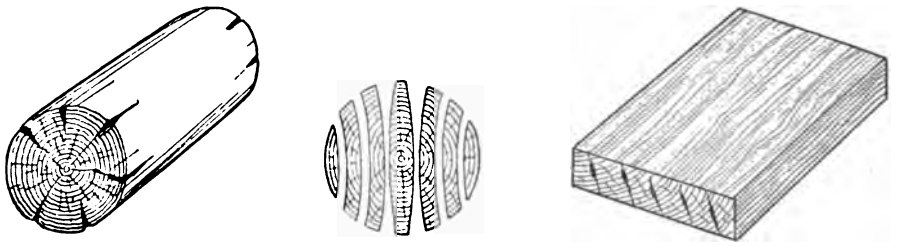
A burled effect is often obtained, especially in oaks and walnuts, by cutting lumber from near the roots of trees, or by cutting through "burls" (knotty growths). Burl is used only in veneers.

Birds-eye maple shows markings for which it is highly prized. The irregularities of the grain are caused by dormant buds which have been covered by later growth.

Color in heart wood is due to chemical substances passing into the cell walls from the outer growing part of the tree. Many woods also darken under exposure to the weather, as walnut, cherry, persimmon, sumac, redwood, mahogany and oak.

9. **Toughness** is the reverse of stiffness. It is the ability to bend without breaking. While wood for a mallet head needs to be heavy in order to have the necessary weight in small dimensions, it must also be tough to resist shock. If a mallet head were made of pine, a wood that shears easily along the fibers, sudden shocks would split it into pieces. A tough wood must stand tests as to strength, hardness, pliability, and elasticity. As a class, hardwoods are nearly three times as tough as soft woods. Hickory, for example, is strong, hard, elastic and pliable, and is one of the toughest of woods.

10. Shrinkage.—The evaporation of water from wood is called "seasoning." This loss decreases the weight, increases the strength and reduces the size. Reduction in size is known as "shrinkage," and varies according to the following conditions: kind of wood, degree of seasoning, and the method of sawing. On account of unequal shrinkage, checking, warping and other defects may develop. As a class, soft woods shrink less than hard woods, and sap wood, as a rule, shrinks more than heart wood.



(a) (b) (c)

Fig. 3.—Some defects caused by shrinkage.

Hardwoods require care in seasoning to guard against defects likely to develop with shrinkage. Either shrinkage or expansion is always taking place, owing to atmospheric conditions. No matter how thoroughly dry lumber is when worked, this change in size must be provided for in construction. Large pieces, such as columns, table legs, etc., are better made of several pieces glued together; table and desk tops are built of several parts; large surfaces are made in panels, or are covered with veneer over a properly made core.

11. Structure.—The structure of a tree is dependent upon the arrangement of plant material during growth. Structure determines all the properties of wood already mentioned, and, as it is a combination of properties, it is discussed under separate heading on page 176.

12. Variable Quality.—Two pieces of lumber of the same kind, or even from the same tree, may vary in their properties. To select any particular kind of lumber for a definite use is not sufficient. Each board must be inspected to determine if the properties common to that kind of lumber are present, to the desired degree. Outside boards contain more sap wood and are less desirable than boards cut

from heart wood. Boards cut on radial lines are superior to those cut tangent to the annual rings. See Figs. 15 and 16. Where no defects are present, the butt log of a tree contains the best and most select lumber. Logs cut from near the top usually make up into lumber of inferior quality, likely to be knotty and brash. Moreover, a board may be brittle and weak from too rapid kiln drying, or it may be unfit for use because it has not been thoroughly seasoned.

It requires experience to distinguish the different kinds of lumber and to determine their qualities.

13. **Cost and Availibility** must be considered in the selection or the specification of lumber for a particular purpose. With our rapidly disappearing forests, these conditions are important factors. The most suitable wood procurable in the locality is commonly used for ordinary purposes. For instance, cottonwood and poplar are not used for fence posts in well timbered regions, but in the Dakotas, where there is little timber, these woods are so used. In these states, limited rainfall and an alkali soil assist in their preservation. Large demands for certain kinds of lumber have so advanced the price that it is no longer practicable to use them as formerly. This condition has made substitution of other and more abundant woods necessary, especially in cabinet-making and carpentry. Also, it has caused workmen to imitate more expensive woods by graining and finishing cheaper woods.

Identification of Woods

14. Such a number of different kinds of commercial woods grow in the United States that their identification even by experienced workmen is difficult. For instance, eight of the thirty-five native pines supply commercial lumber, some of which very closely resemble one another. There are six of the thirty-six oaks that produce marketable lumber. There are eight different kinds of hickory and six different kinds of ash. From this it will be seen that the ability to distinquish the different kinds of lumber will require study and exercise of judgment. The workman should be familiar with the names and characteristics of woods, especially those native to the locality, and those in common use.

Wood samples may be collected to assist in becoming familiar with the different woods. These should be of a convenient size, as $\frac{3}{8}$"x2"x4".

Note.—The United States Forest Service has prepared sets showing over sixty of our common commercial woods. These sets are in the form of traveling exhibits, excellently mounted, and include photographs of lumbering activities. Smaller sets may be had by schools for their permanent use.

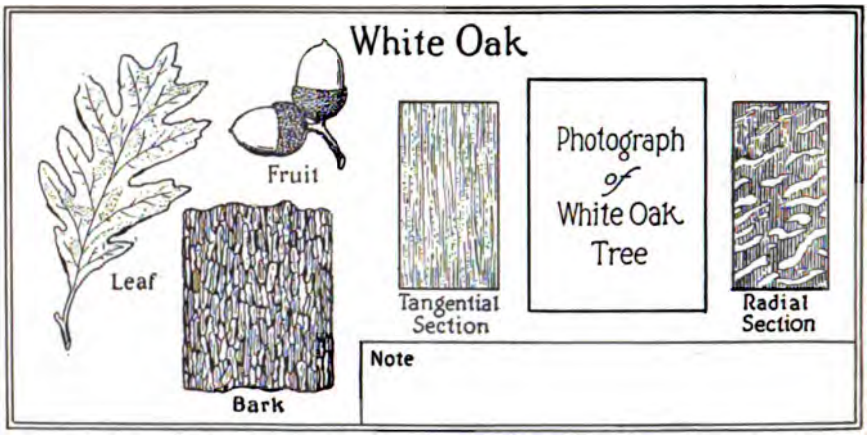


Fig. 4.

In studying the trees common to any locality, a series of tree charts like that suggested in Fig. 4 should be made. Mounted on heavy manilla paper or cardboard, they form a valuable aid in the study of the different woods and assist in their identification.

Structure and Appearance of Wood *

15. "The structure of wood affords the only reliable means of distinguishing the different kinds. Color, weight, smell, and other appearances, which are often direct or indirect results of structure, may be helpful in this distinction but can not be relied upon entirely. In addition, structure underlies nearly all the technical properties of this important product and furnishes an explanation why one piece differs as to these properties from another.

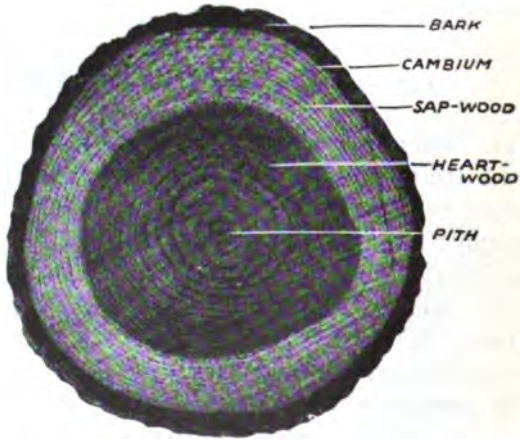


Fig. 5.

Structure explains why oak is heavier, stronger, and tougher than pine; why it is harder to saw and plane, and why it is so much more difficult to season without injury. From its less porous structure alone, it is evident that a piece of a young and thrifty oak is stronger than the

*Adapted from Forestry Bulletin No. 10, U. S. Department of Agriculture.

porous wood of an old or stunted tree; or that Georgia or longleaf pine excels white pine in weight and strength. Keeping especially in mind the arrangement and direction of the fibers of wood, it is clear at once why knots and "crossgrains" interfere with the strength of timber.

It is due to structural peculiarities that "honeycombing" occurs in rapid seasoning, that "checks" or cracks extend radially and follow pith rays, that tangent or "bastard" boards shrink and warp more than quartered lumber. These same peculiarities enable cherry and oak to take a better finish than basswood or coarse grained pine.

Moreover, structure, aided by color, determines the beauty of wood. All the pleasing figures, whether in a hard-pine ceiling, a desk of quartered oak, or in the beautiful panels of "curly" or "bird's-eye" maple decorating the salon of a ship or a palace car, are due to differences in the structure of the wood. Knowing this, the appearance of any particular section can be foretold, and almost unlimited choice and combination are thereby suggested.

Thus a knowledge of structure not only enables us to distinguish the different woods, judge as to their qualities, and explain the causes of their beauty, but it also becomes an invaluable aid to the thoughtful worker, guiding him to a more careful selection and a more perfect use of material.

16. Classes of Trees.—The timber of the United States is furnished by three well-defined classes of trees: the needle-leaved, naked-seeded conifers (pine, cedar, etc.), the dicotyledonous (with two seed leaves), broad-leaved trees (oak, poplar, etc.), and to an inferior extent by the monocotyledonous (with one seed leaf), palms, yuccas, and their allies, which last are confined to the most southern parts of the country.

Broad-leaved trees are also known as deciduous trees, although especially in warm countries, many of them are evergreen,[1] while the conifers are commonly termed "evergreens," although the larch, bald cypress, and others shed their leaves every fall, and even the names "broad-leaved" and "coniferous," though perhaps the most satisfactory, are not at all exact, for the conifer ginkgo has broad leaves and bears no cones.

In the lumber trade, the woods of broad-leaved trees are known as "hardwoods," though poplar is as soft as pine, and the coniferous woods are "softwoods," notwithstanding that yew ranks high in hardness even when compared to "hardwoods."

Both in the number of different kinds of trees or species and still more in the importance of their product the conifers and broad-leaved trees far excel the palms and their relatives.

In the manner of growth both conifers and broad-leaved trees behave alike, adding each year a new layer of wood which covers the old wood in all parts of the stem and limbs. Thus the trunk continues to grow in thickness throughout the life of the tree by additions (annual rings) which in temperate climates are, barring accidents, accurate records of the tree. With the palms and their relatives the stem remains generally of the same diameter, the tree of a hundred years being as thick as it was at ten years, the growth of these being only at the top. Even where a peripheral increase takes place, as in the yuccas, the wood is not laid on in well-defined layers; the structure remains irregular throughout.

[1] In Ceylon even the cultivated cherry has become an evergreen.

Though alike in their manner of growth, and therefore similar in their general makeup, conifers and broad-leaved trees differ markedly in the details of their structure and the character of their wood. The wood of all conifers is very simple in its structure, the fibers composing the main part of the wood, being all alike and their arrangement regular. The wood of broad-leaved trees is complex in structure; it is made up of several different kinds of cells and fibers and lacks the regularity of arrangement so noticeable in the conifers. This difference is so great that in a study of wood structure it is best to consider the two kinds separately.

17. Wood of Coniferous Trees.—Examining a smooth cross section or end face of a well-grown log of Georgia pine or Norway pine, we distinguish an envelope of reddish, scaly bark, a small whitish pith at the center, and between these the wood in a great number of concentric rings.

18. Bark and Pith.—The bark of a pine stem is thickest and roughest near the base, decreases rapidly in thickness from 1½ inches at the stump to one-tenth inch near the top of the tree, and forms in general about 10 to 15 per cent of the entire trunk.

The pith is quite thick, usually one-eighth to one-fifth inch in Norway pine and in the southern species, though much less so in white pine, and is very thin, one-fifteenth to one twenty-fifth inch in cypress, cedar, and larch.

In woods with a thick pith, this latter is finest at the stump, grows rapidly thicker upward, and becomes thinner again in the crown and limbs, the first 1 to 5 rings adjoining it behaving similarly.

19. Sap and Heart Wood.—A zone of wood next to the bark, 1 to 3 or more inches wide, and containing 30 to 50 or more annual rings, is of lighter color; this is the sapwood, the inner, darker part of the log being the heartwood. In the former many cells are active and store up starch and otherwise assist in the life processes of the tree, although only the last or outer layer of cells the cambium, forms the growing part and the true life of the tree. In the heartwood all cells are lifeless cases, and serve only the mechanical function of keeping the tree from breaking under its own great weight, or from being laid low by the winds.

The darker color of the heartwood is due to infiltration of chemical substances into the cell walls, but the cavities of the cells in pine are not filled up, as is sometimes believed, nor do their walls grow thicker, nor is their wall any more lignified than in the sapwood. Sapwood varies in width and in the number of rings which it contains, even in different parts of the same tree; the same year's growth which is sapwood in one part of a disk may be heartwood in another. Sapwood is widest in the main part of the stem and varies often within considerable limits, and without apparent regularity. Generally it becomes narrower toward the top and in the limbs, its width varying with the diameter, and being least, in a given disk, on the side which has the shortest radius. Sapwood of old and stunted pines is composed of more rings than that of young and thrifty

specimens. Thus in a pine 250 years old, a layer of wood or annual ring does not change from sapwood to heartwood until seventy or eighty years after it is formed, while in a tree 100 years old, or less, it remains sapwood only from thirty to sixty years. The width of the sapwood varies considerably for different kinds of pines; it is small for longleaf and white pine, and great for loblolly and Norway pines. Occupying the peripheral part of the trunk the proportion which it forms of the entire mass of the stem is always great. Thus even in old trees of longleaf pine the sapwood forms about 40 per cent of the merchantable log, while in the loblolly and in all young trees the bulk of the wood is sapwood.

20. The Annual or Yearly Ring.—The concentric, annual, or yearly rings, which appear on the end face of a log are cross sections of so many thin layers of wood. Each such layer forms an envelope around its inner neighbor, and is in turn covered by the adjoining layer without, so that the whole stem is built up of a series of thin hollow cylinders, or rather cones. A new layer of wood is formed each season, covering the entire stem, as well as all the living branches. The thickness of this layer, or the width of the yearly ring, varies greatly in different trees and also in different parts of the same tree. In a normally grown, thrifty pine log the rings are widest near the pith, growing more and more narrow toward the bark. Thus the central 20 rings in a disk of an old longleaf pine may each be one-eighth to one-sixth inch (3 to 4 mm.) wide, while the 20 rings next to the bark may average only one-thirtieth inch (0.7 mm.). In our forest trees rings of one-half inch in width occur only near the center in disks of very thrifty trees of both conifers and hard woods; one-twelfth inch represents good thrifty growth, and the minimum width of about one two-hundredths inch (0.2 mm.) is often seen in stunted spruce and pine. The average width of rings in well-grown old white pine will vary from one-twelfth to one-eighteenth inch, while in the slower growing longleaf pine it may be one twenty-fifth to one-thirtieth of an inch. The same layer of wood is widest near the stump in very thrifty young trees, especially if grown in the open park, but in old forest trees the same year's growth is wider in the upper part of the tree, being narrowest near the stump and often also near the very tip of the stem. Generally the rings are widest near the center, growing narrower towards bark. In logs from stunted trees the order is often reversed, the interior rings being thin and the outer rings widest. Frequently, too, zones or bands of very narrow rings, representing unfavorable periods of growth, disturb the general regularity. Few trees, even among pines, furnish a log with truly circular cross section; usually it is an oval, and at the stump commonly quite an irregular figure. Moreover, even in very regular or circular disks the pith is rarely in the center, and frequently one radius is conspicuously longer than its opposite, the width of some of the rings, if not all, being greater on one side than on the other. This is nearly always so in the limbs, the lower radius exceeding the upper.

In extreme cases, especially in the limbs, a ring is frequently conspicuous on one side and almost or entirely lost to view on the other. Where the rings are extremely narrow, the dark portion of ring is often wanting, the color being quite uniform and light. The great regularity or irregularity of the annual rings has much to do with the technical qualities of the timber.

21. Spring and Summer Wood.—Examining the rings more closely, it is noticed that each ring is made up of an inner, softer, light-colored, and an outer, or peripheral, firmer and darker-colored portion. Being formed in the fore part of the season, the inner, light-colored part is termed spring wood, the outer, darker portion being the summer wood of the ring. Since the latter is very heavy and firm, it determines to a large extent the weight and strength of the wood, and as its darker color influences the shade of color of the entire piece of wood, this color effect becomes a valuable aid in distinguishing heavy and strong from light and soft pine wood. In most hard pines, like the longleaf, the dark summer wood appears as a distinct band, so that the yearly ring is composed of two sharply defined bands—an inner, the spring wood, and an outer, the summer wood. But in some cases, even in hard pines, and normally in the wood of white pines, the spring wood passes gradually into the darker summer wood, so that a sharply defined line occurs only where the spring wood of one ring abuts against the summer wood of its neighbor. It is this clearly defined line which enables the eye to distinguish even the very narrow rings in old pines and spruces. In some cases, especially in the trunks of Southern pines, and normally on the lower side of pine limbs, there occur dark bands of wood in the spring wood portion of the ring, giving rise to false rings which mislead in a superficial counting of rings. In the disks cut from limbs these dark bands often occupy the greater part of the ring and appear as "lunes" or sickle-shaped figures. The wood of these dark bands is similar to that of the true summer wood—the cells have thick walls, but usually lack the compressed or flattened form.

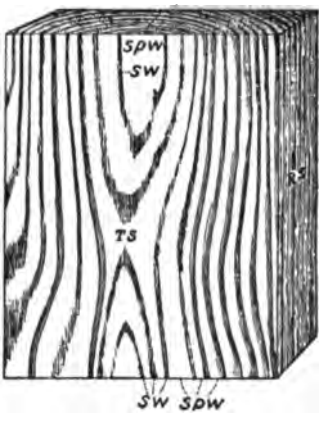


Fig. 6.—Board of pine. CS, cross section; RS, radial section; TS, tangential section; Sw, summer wood; Spw, spring wood.

Normally, the summer wood forms a greater proportion of the ring in the part of the tree formed during the period of thriftiest growth. In an old tree this proportion is very small in the first 2 to 5 rings about the pith, and also in the part next to the bark, the intermediate part showing a greater proportion of summer wood. It is also greatest in a disk taken from near the stump and decreases upward in the stem, thus fully accounting for the difference in weight and firmness of the wood of these different parts. In the longleaf pine the summer wood often forms scarcely 10 per cent of the wood in the central 5 rings; 40 to 50 per cent of the next 100 rings; about 30 per cent in the next 50, and only about 20 per cent in the 50 rings next to the bark. It averages 45 per cent of the wood of the stump and only 24 per cent of that of the top.

Sawing the log into boards, the yearly rings are represented on the board faces of the middle board (radial sections) by narrow, parallel stripes (see Fig. 6), an inner, lighter stripe, and its outer, darker neighbor always corresponding to one annual ring.

On the faces of the boards nearest the slab (tangential or "bastard" boards) the several years' growth should also appear as parallel, but much broader stripes. This they do only if the log is short and very perfect. Usually a variety of pleasing patterns is displayed on the boards, depending on the position of the saw cut, and on the regularity of growth of the log (see Fig. 6).

Where the cut passes through a prominence (bump or crook) of the log, irregular, concentric circlets and ovals are produced, and on almost all tangent boards, arrow, or V-shaped forms occur.

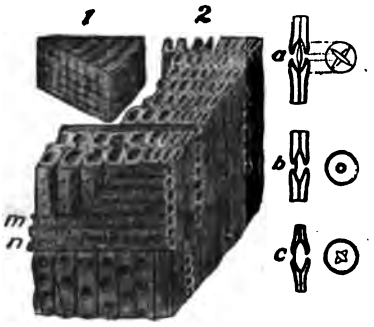


Fig. 7.—Wood of spruce. 1, three-fourths size; 2, small part of the ring magnified 75 times. The vertical tubes are wood fibers, in this case all "tracheids." m, medullary or pith ray; n, transverse tracheids of pith ray; a, b, and c, bordered pits of the tracheids, more enlarged.

22. Anatomical Structure.—Holding a well-smoothed disk, or cross section one-eighth inch thick toward the light, it is readily seen that pine wood is a very porous structure. If viewed with a strong magnifier, the little tubes, especially in the spring wood of the rings, are easily distinguished and their arrangement in regular straight radial rows is apparent. Scattered through the summer wood portion of the rings, numerous irregular grayish dots (the resin ducts) disturb the uniformity and regularity of the structure. Magnified 75 times, a piece of spruce, which is similar to pine, presents a picture like that shown in Fig. 7. Only short pieces of the tubes or cells of which the wood is composed are represented in the picture.

The total length of these fibers is one-twentieth to one-fifth inch, being smallest near the pith, and is 50 to 100 times as great as their width (Fig. 8.) They

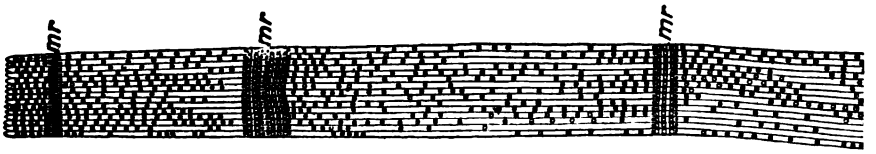


Fig. 8.—Group of fibers from pine wood. Partly schematic. The little circles are "border pits" (see Fig. 7, a-c). The transverse rows of square pits indicate the places of contact of these fibers and the cells of the neighboring pith rays. Magnified about 38 times.

are tapered and closed at their ends, polygonal, or rounded and thin walled, with large cavity, lumen or internal space in the spring wood, thick walled and flattened radially with the internal space or lumen much reduced in the summer wood. (See right-hand portion of Fig. 7.) This flattening, together with the thicker walls of the cells which reduces the lumen, causes the greater firmness and darker color of the summer wood—there is more material in the same volume. As shown in the figure, the tubes, cells, or "tracheids" are decorated on their walls by circlet-like structures, the "bordered pits," sections of which are seen more magnified

at a, b, and c, Fig. 7. These pits are in the nature of pores, covered by very thin membranes, and serve as waterways between the cells or tracheids.

The dark lines on the side of the smaller piece (1, Fig. 7) appear when magnified (in 2, Fig. 7) as tiers of 8 to 10 rows of cells, which run radially (parallel to the rows of tubes or tracheids) and are seen as bands on the radial face and as rows of pores on the tangential face. These bands or tiers of cell rows are the medullary rays or pitch rays, and are common to all our lumber woods. In the pines and other conifers they are quite small, but they can readily be seen, even without a magnifier, if a radial surface of split wood (not smoothed) is examined. The entire radial face will be seen almost covered with these tiny structures, which appear as fine but conspicuous cross lines. As shown in Fig. 7 the cells of the medullary or pith rays are smaller and very much shorter than the wood fibers or tracheids and their long axis is at right angles to that of the fibers. In pines and spruces the cells of the upper and lower rows of each tier or pith ray have "bordered" pits like those of the wood fibers or tracheids proper, but the cells of the intermediate rows, and of all rows in the rays of cedars, etc., have only "simple" pits, i. e., pits devoid of the saucer-like "border" or rim.

In pine, many of the pith rays are larger than the majority, each containing a whitish line, the horizontal resin duct, which, though much smaller, resembles the vertical ducts seen on the cross section. The larger vertical resin ducts are best observed on removal of the bark from a fresh piece of white pine, cut in winter, where they appear as conspicuous white lines, extending often for many inches up and down the stem.

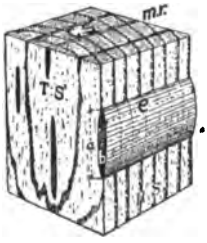


Fig. 9.—Block of oak. C. S., cross section; R. S., radial section; T. S., tangential section; m. r., medullary or pith ray; a, height, b, width, and e, length of a pith ray.

Neither the horizontal nor the vertical resin ducts are vessels or cells, but are openings between cells, i e., intercellular spaces, in which the resin accumulates, freely oozing out when the ducts of a fresh piece of sapwood are cut. They are present only in our coniferous woods, and even here they are restricted to pine, spruce, and larch, and are normally absent in fir, cedar, cypress, and yew.

Altogether the structure of coniferous wood is very simple and regular, the bulk being made up of the small fibers called tracheids, the disturbing elements of pith rays and resin ducts being insignificant, and hence the great uniformity and great technical value of coniferous wood.

28. Wood of Broad-Leaved Trees.—On a cross section of oak, the same arrangement of pith and bark, of sapwood and heartwood, and the same disposition of the wood in well-defined concentric or annual rings occurs, but the rings are marked by lines, or rows, of conspicuous pores or openings which occupy the greater part of the spring wood of each ring (see Fig. 9, also Fig. 11) and are, in fact, the hollows of vessels through which the cut has been made. On the radial section, or quarter-sawed board, the several layers appear as so many parallel stripes (see Fig. 10); on the tangential section or "bastard" face, patterns similar to those mentioned for pine wood are observed. But while the patterns in hard pine are marked by the darker summer wood and are composed of plain, alter-

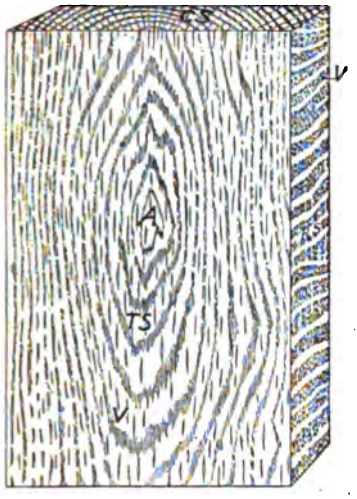


Fig. 10.—Board of oak. CS, cross section; RS, radial section; TS, tangential section; V, vessels or pores, cut through; A, slight curve in log which appears in section as an islet.

nating stripes of darker and lighter wood, the figures in oak (and other broad-leaved woods) are due chiefly to the vessels, those of the spring wood in oak being the most conspicuous, so that in an oak table the darker, shaded parts are the spring wood, the lighter, uncolored parts the summer wood.

On closer examination of the smoothed cross section of oak, the spring wood part of the ring is found to be formed, in great part, of pores; large, round, or oval openings made by the cut through long vessels. These are separated by a grayish and quite porous tissue (see Fig. 11), which continues here and there in the form of radial, often branched, patches (not the pith rays) into and through the summer wood to the spring wood of the next ring. The large vessels of the spring wood, occupying 6 to 10 per cent of the volume of a log in very good oak, and 25 per cent or more in inferior and narrow-ringed lumber, are a very important feature, since it is evident that the greater their share in the volume, the lighter and weaker the wood. They are smallest near the pith, and grow wider outward; they are

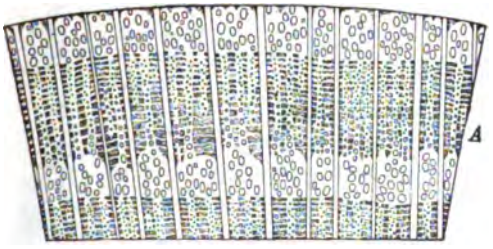


Fig. 11.—Cross section of oak magnified about 4 times.

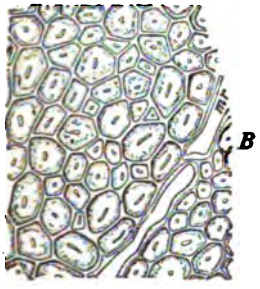


Fig. 12.—Portion of the firm bodies of fibers with two cells of a small pith ray mr. Highly magnified.

wider in the stem than limb and seem to be of indefinite length, forming open channels in some cases probably as long as the tree itself.

Scattered through the radiating gray patches of porous wood are vessels similar to those of the spring wood, but decidedly smaller. These vessels are usually fewer and larger near the spring wood, and smaller and more numerous in the outer portions of the ring. Their number and size can be utilized to distinguish the oaks classed as white oaks from those classed as black and red oaks; they are fewer and larger in red oaks, smaller but much more numerous in white oaks. The summer wood, except for these radial grayish patches, is dark colored and firm. This firm portion, divided into bodies or strands by these patches of porous wood and

also by fine wavy concentric lines of short, thin-walled cells (see Fig. 11), consists of thick-walled fibers (see Fig. 12) and is the chief element of strength in oak wood. In good white oak it forms one-half and more of the wood; it cuts like horn, and the cut surface is shiny and of a deep chocolate-brown color. In very narrow-ringed wood and in inferior red oak it is usually much reduced in quantity as well as quality.

The pith rays of the oak, unlike those of coniferous woods, are at least in part very large and conspicuous (see Fig. 9, their height indicated by the letter **a**, and their width by the letter **b**). The large medullary rays of oak are often twenty and more cells wide and several hundred cell rows in height which amount commonly to one or more inches. These large rays are conspicuous on all sections. They appear as long, sharp grayish lines on the cross section, as short, thick lines, tapering at each end, on the tangential or "bastard" face, and as broad, shiny bands the "mirrors" on the radical section. In addition to these coarse rays, there is also a large number of small pith rays, which can be seen only when magnified. On the whole, the pith rays form a much larger part of the wood than might be supposed. In specimens of good white oak it has been found that they formed about 16 to 25 per cent of the wood.

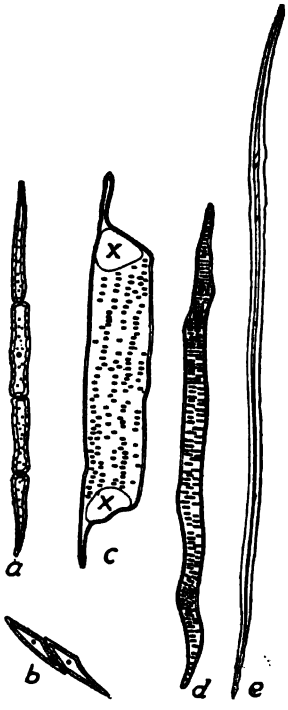


Fig. 13. — Isolated fibers and cells. a, four cells of wood parenchyma; b, two cells from a pith ray; c, a single joint or cell of a vessel, the openings x leading into its upper and lower neighbors; d, tracheid; e, wood fiber proper.

24. Minute Structure.—If a well-smoothed, thin disk, or cross section of oak (say one-sixteenth inch thick) is held up to the light, it looks very much like a sieve, the pores or vessels appearing as clean-cut holes; the spring wood and gray patches are seen to be quite porous, but the firm bodies of fibers between them are dense and opaque. Examined with the magnifier it will be noticed that there is no such regularity of arrangement in straight rows as is conspicuous in the pine; on the contrary, great irregularity prevails. At the same time, while the pores are as large as pin holes, the cells of the denser wood, unlike those of pine wood, are too small to be distinguished. Studied with the miscroscope, each vessel is found to be a vertical row of a great number of short, wide tubes, joined end to end (Fig. 13, c). The porous spring wood and radial gray tracts are partly composed of small vessels, but chiefly of tracheids like those of pine, and of shorter cells, the "wood parenchyma," resembling the cells of the medullary rays. These latter, as well as the fine concentric lines mentioned as occurring in the summer wood, are composed entirely of short, tube-like parenchyma cells with square or oblique ends (Fig. 13, **a** and **b**). The wood fibers proper, which form the dark, firm bodies referred to, are very fine, thread-like cells one twenty-fifth to one-tenth inch long, with a wall com-

monly so thick that scarcely any empty internal space or lumen remains (Fig. 13, and e in Fig. 12).

If instead of oak a piece of poplar or basswood (Fig. 14) had been used in this study, the structure would have been found to be quite different. The same kinds of cell-elements, vessels, etc., are, to be sure, present but their combination and arrangement is different, and thus from the great variety of possible combinations results the great variety of structure and, in consequence, of the qualities which distinguish the wood of broad-leaved trees. The sharp distinction of sapwood and heartwood is wanting; the rings are not so clearly defined, the vessels of the wood are small, very numerous, and rather evenly scattered through the wood of the annual ring, so that the distinction of the ring almost vanishes and the medullary or pith rays, in poplar, can be seen, without being magnified, only on the radial section."

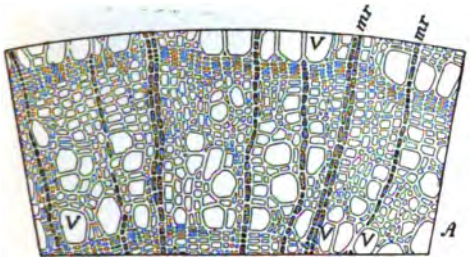


Fig. 14.—Cross section of basswood (magnified). v, vessels; mr, pith rays.

Plain and Quarter-Sawed Lumber

25. Plain Sawed Lumber.—In making plain sawed lumber, a log is first "squared up" and then successive cuts are taken, each cut being parallel to the previous one. See Fig. 15. This is the easiest way to saw a log in the average mill and produces the most usable lumber per log. Plain lumber will warp more readily and is more liable to check than quarter-sawed lumber. When lumber checks, it splits along the medullary rays. In plain-sawed lumber, the medullary rays do not run parallel to the surface of the boards but at an angle. When the board shrinks, it is liable to check along these rays. See medullary rays in Fig. 9.

Fig. 15.

When a board is plain-sawed, the annual rings are shortest in

length next the surface towards the heartwood. When it shrinks, the outside annual rings or longest lines of growth shrink most and the board is warped or cupped outwards. See b in Fig. 3.

26. Quarter-Sawed Lumber.— Lumber sawed with the surface of the board parallel to the medullary rays shows the beautiful markings of these rays. Such lumber is said to be quarter-sawed and does not check badly. See Fig. 16.

It does not tend to warp because the annual rings cross the board almost squarely, and shrink uniformly.

Fig. 16.

Seasoning

27. The process of reducing the amount of moisture in wood is called seasoning. Green, or freshly cut, timber may contain as much as 50 per cent water. Different parts of a tree contain different amounts of water; the heart wood least, and the sap wood most. In the process of seasoning, considerable change takes place in lumber. Its strength is increased, as in also its stiffness and hardness; weight is very much reduced; the lumber is less liable to shrink, and also less apt to decay. These changes tend to make the lumber more valuable, and therefore unseasoned lumber is seldom used.

The two methods of seasoning which are commonly used are air drying and kiln drying. Air dried lumber may contain from 10 to 25 per cent of moisture, depending upon climatic conditions. This is considered dry enough for all ordinary uses such as framing timber, structural and building materials. See Fig. 17. For more exacting uses, kiln drying, which reduces the amount of moisture to from 5 to 10 per cent, is required. See Fig. 18. Seasoning may be continued at a high temperature until less than 1 per cent water is left. It is then called "bone dry" lumber. Bone dry lumber is not desirable, since the high temperature necessary to produce it injures the wood

fibers. It has a baked, lifeless appearance, is brittle and lacks strength.

(a) Lumber on stick; (b) Lumber piled edge to edge; (c) Lumber stacked on end.
Fig. 17.

Soft woods may be kiln dried with much less danger from checking than hard woods. Much lumber goes at once from the saw-mill to the dry kiln to reduce its weight before shipping.

In artificial drying, temperatures of from 150 to 185 degrees Fahrenheit are usually employed. Most hard woods are air dried from four to six months before being kiln dried. During this period the first shrinkage takes place and renders them less liable to check and warp.

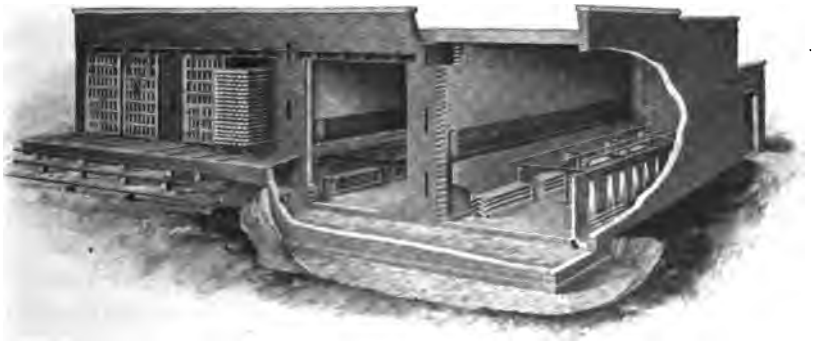


Fig. 18.—Dry kiln.

No matter how dry lumber is when taken from the kiln, it quickly absorbs moisture from the atmosphere until it contains from eight to ten per cent. To prevent excessive changes in the moisture content, it should be properly cared for. A damp basement is no place for the storage of lumber. Lumber changes shape rapidly unless properly piled, so that it will lay straight. Moreover, it should be piled so as to admit free circulation of air.

Dressed Lumber

28. Lumber for any kind of fine work is usually dressed on two sides; that is, planed smooth and even with a machine planer on both of its faces. In the trades, abbreviations to designate the planing done on boards are used, as, S-2-S, which means planed two surfaces and sized to thickness; S-1-S which means planed on one surface and sized to thickness; S-4-S which means planed on both surfaces and edges and sized to thickness and width; S-1-S-1-E, which means planed on one surface and one edge and sized to thickness and width.

Lumber dimensions are always given in the order of thickness, width and length. An order for a board $\frac{7}{8}$ inches thick, 8 inches wide and 12 feet long would read: 1 Pc. $\frac{7}{8}$″x8″x12′.

(Note that the sign (″) is used to denote inches and the sign (′) to denote feet.)

The standard thicknesses of lumber as it comes from the saw-mill are $\frac{5}{8}$″, $\frac{3}{4}$″, 1″, $1\frac{1}{4}$″, $1\frac{1}{2}$″ and 2″. Lumber loses about $\frac{1}{8}$″ in being dressed; that is, a board sawed in the mill to one inch, when S-2-S measures about $\frac{7}{8}$″.

29. **Board Measure.**—To find the number of board feet in a piece one inch or less in thickness, the length in feet is multiplied by the width in inches and the product divided by twelve. If the lumber is over one inch in thickness, the product is multiplied by the thickness before dividing by twelve.

NOTE.—The lumber rule used for measuring lumber, is explained in Art. 64, Sec. 4. Also, the use of the Essex Board Measure as found on the back of the steel square is explained in Art. 21, Sec. 4.

Defects in Lumber

The most serious defects in structural timbers are rot, knots, shake and cross grain.

30. **Rot** is a disease, and rotten wood is usually the result of either "wet rot" or "dry rot." Wet rot attacks green trees or lumber, the excess of moisture present furnishing the proper conditions for its development. The wood becomes discolored and rotten. Dry rot is one of the most destructive diseases that attack lumber. It grows on wood in damp places and causes the wood to become crumbly when

dry or spongy when wet. Keeping lumber dry checks the ravages of dry rot. Decay in wood is considered a defect and such wood is said to be **doaty.**

31. Knots are objectionable in proportion to the degree in which they affect the usefulness of lumber. They are classified as:

1. Sound knot—one which is solid, as hard as the wood surrounding it, and that will not come out.
2. Loose knot—one loosely held in place.
3. Pith knot—a sound knot having a pith hole less than ¼" in diameter.
4. Encased knot—one surrounded wholly or in part by bark or pitch.
5. Rotten knot—one less hard than the wood surrounding it.
6. Pin knot—a sound knot ½" or less in diameter.
7. Standard knot—sound and less than 1½" in diameter.
8. Large knot—sound, but more than 1½" in diameter.
9. Round knot—a knot oval or circular in form.
10. Spike knot—a knot sawn through lengthwise.

32. Pitch Pockets are openings in the grain of wood containing pitch or bark.

33. Pitch Streaks are accumulations of pitch sufficient to develop a definite streak.

34. Shake refers to checking of the standing timber either along the line of the medullary rays or annual rings. There are two classes of shake:

Star Shake. A sudden fall in temperature causes the outside layers of a tree, which are filled with sap, to contract more rapidly than the inner portions. As a result, the tree splits, the check running up and down the tree along its radius.

Wind shake or cup shake is caused by a sudden rise in temperature or by wind. When temperature rises suddenly the outer portion of a tree expands rapidly and checks away from the central portion along the annual rings. Strong wind may produce the same effect. Shake seriously injures the quality of lumber.

35. **Cross Grain** lumber is sawed at an angle to the direction of growth. It cannot be used where much strength is required and for this reason is classed as defective.

The Grading of Lumber

36. Grading of lumber is necessary for manufacturers to maintain uniformity in production, and to adapt their product to the needs of the customer. A system of uniform grading enables each manufacturer to classify his output into grades. By this system the purchaser secures the same value in corresponding grades of lumber from different manufacturers.

Custom varies in the matter of grading lumber. Certain lumber manufacturers' associations have adopted grading rules suited to their product. At the end of this section a list of the associations that have adopted standard grading rules is given. Copies of these rules may be procured from the various associations.

In general, four standard grades of lumber are recognized. These grades are "Number 1," "Number 2," "Common Boards," and "Culls." These classifications are general and are often subgraded for different purposes.

37. **Number 1** is a grade of lumber that is considered practically perfect stock, though in large dimensions small and unimportant blemishes may be allowed. These blemishes in a board are usually restricted to not more than one inch of sap, a small sound knot, or slight discoloration. Not more than one of these blemishes is allowed to a board.

38. **Number 2** lumber generally allows two sound knots, an inch of sap, or an equivalent blemish.

39. **Common Boards.**—In this grade there may be three or four sound knots to a board, but two-thirds of one side of the board must be clear stock.

40. **Culls.**—This is the lowest grade and contains all commercial lumber below Grade 3 (common boards). In this grade, one-half the board must be usable.

41. There can be no permanent grading of lumber, as lumber standards must be adjusted continually to meet the conditions of diminishing output and lower quality. The chief reason for this is that the forests from which lumber may be obtained in commercial quantities are being cut away much faster than nature can replace them.

Lumber Associations That Have Adopted Standard Rules of Grading

California Sugar and White Pine Association, San Francisco, Calif.
Georgia-Florida Sawmill Association of the United States, Jacksonville, Fla.
Hardwood Manufacturers Association of the United States, Cincinnati, Ohio.
Maple Flooring Manufacturers Association, Chicago, Ill.
National Hardwood Lumber Manufacturers Association, Chicago, Ill.
Northern Hemlock and Hardwood Manufacturers Association, Wausau, Wis.
Northern Pine Manufacturers Association, Minneapolis, Minn.
North Carolina Pine Manufacturers Association, Norfolk, Va.
Oak Flooring Manufacturers Association, Detroit, Mich.
Redwood Manufacturers Association, San Francisco, Calif.
Southern Cypress Manufacturers Association, New Orleans, La.
Spruce Manufacturers Association, New York City, N. Y.
West Coast Lumber Manufacturers Association, Tacoma, Wash.
Western Pine Manufacturers Association, Spokane, Wash.
Yellow Pine Manufacturers Association, St. Louis, Mo.

A List of the More Important Woods of the United States*

A.—Coniferous Woods (Soft Woods).

42. Soft woods are of simple and uniform structure, generally light, soft but stiff; abundant in suitable dimensions and forming by far the greatest part of all the lumber used.

CEDAR

43. Light, soft, stiff, not strong, of fine texture; sap and heartwood distinct, the former lighter, the latter a dull, grayish brown, or red. The wood seasons rapidly, shrinks and checks but little, and is very durable. Used like soft pine, but owing to its great durability preferred for shingles, etc. Small sizes used for posts, ties,

*Adapted from Forestry Bulletin No. 10, U. S. Department of Agriculture.

etc.[1] Cedars usually occur scattered, but they form, in certain localities, forests of considerable extent.

a. **White Cedars.**—Heartwood a light grayish brown.

44. White Cedar (Thuya occidentalis) (arbor vitae): Scattered along streams and lakes, frequently covering extensive swamps; rarely large enough for lumber, but commonly used for posts, ties, etc. Maine to Minnesota and northward.

45. Canoe Cedar (Thuya gigantea) (red cedar of the West): In Oregon and Washington a very large tree, covering extensive swamps; in the mountains much smaller, skirting the water courses; an important lumber tree. Washington to northern California and eastward to Montana.

46. White Cedar (Chamaecyparis thyoides): Medium-sized tree, wood very light and soft. Along the coast from Maine to Mississippi.

47. White Cedar (Chamaecyparis lawsoniana) (Port Orford cedar, Oregon cedar, Lawson's cypress, ginger pine): A very large tree, extensively cut for lumber; heavier and stronger than the preceding. Along the coast line of Oregon.

48. White Cedar (Libocedrus decurrens) (incense cedar): A large tree, abundantly scattered among pine and fir; wood fine grained. Cascades and Sierra Nevada of Oregon and California.

b. **Red Cedars.**—Heartwood red.

49. Red Cedar (Juniperus virginiana) (Savin juniper): Similar to white cedar, but of somewhat finer texture. Used in cabinet work, in cooperage, for veneers, and especially for lead pencils, for which purpose alone several million feet are cut each year. A small to medium sized tree scattered through the forests, or, in the West, sparsely covering extensive areas (cedar brakes). The red cedar is the most widely distributed conifer of the United States, occurring from the Atlantic to the Pacific and from Florida to Minnesota, but attains a suitable size for lumber only in the Southern, and more especially the Gulf States.

50. Redwood (Sequoia sempervirens): Wood in its quality and uses like white cedar; the narrow sapwood whitish; the heartwood light red, soon turning to brownish red when exposed. A very large tree, limited to the coast ranges of California, and forming considerable forests, which are rapidly being converted into lumber.

CYPRESS

51. Cypress (Taxodium distichum) (bald cypress; black, white, and red cypress): Wood in appearance, quality, and uses similar to white cedar. "Black cypress" and "white cypress" are heavy and light forms of the same species. The cypress is a large deciduous tree, occupying much of the swamp and overflow land along the coast and rivers of the Southern States.

[1] Since almost all kinds of woods are used for fuel and charcoal, and in the construction of fences, sheds, barns, etc., the enumeration of these uses has been omitted in this list.

FIR

52. This name is frequently applied to wood and to trees which are not fir; most commonly to spruce, but also, especially in English markets, to pine. It resembles spruce, but it is easily distinguished from it, as well as from pine and larch, by the absence of resin ducts. Quality, uses, and habits similar to spruce.

53. Balsam Fir (Abies balsamea): A medium-sized tree scattered throughout the Northern pineries; cut, in lumber operations, whenever of sufficient size, and sold with pine or spruce. Minnesota to Maine and northward.

54. White Fir (Abies grandis and Abies concolor): Medium to very large sized tree, forming an important part of most of the Western mountain forests, and furnishing much of the lumber of the respective regions. The former occurs from Vancouver to central California and eastward to Montana; the latter from Oregon to Arizona and eastward to Colorado and New Mexico.

55. White Fir (Abies amabilis): Good-sized tree, often forming extensive mountain forests. Cascade Mountains of Washington and Oregon.

56. Red Fir (Abies nobilis) (not to be confounded with Douglas fir; see Art. 86): Large to very large tree, forming with A. amabilis extensive forests on the slope of the mountains between 3000 and 4000 feet elevation. Cascade Mountains of Oregon.

57. Red Fir (Abies magnifica): Very large tree, forming forests about the base of Mount Shasta. Sierra Nevada of California, from Mount Shasta southward.

HEMLOCK

58. Light to medium weight, soft, stiff but brittle, commonly crossgrained, rough and splintery; sapwood and heart wood not well defined; the wood of a light, reddish-gray color, free from resin ducts, moderately durable, shrinks and warps considerably, wears rough, retains nails firmly. Used principally for dimension stuff and timbers. Hemlocks are medium to large sized trees, commonly scattered among broad-leaved trees and conifers, but often forming forests of almost pure growth.

59. Hemlock (Tsuga canadensis): Medium-sized tree, furnishes almost all the hemlock of the Eastern market. Maine to Wisconsin; also following the Alleghanies southward to Georgia and Alabama.

60. Hemlock (Tsuga mertensiana): Large-sized tree, wood claimed to be heavier and harder than the Eastern form and of superior quality. Washington to California and eastward to Montana.

LARCH OR TAMARACK

61. Wood like the best of hard pine, both in appearance, quality, and uses, and owing to its great durability somewhat preferred in shipbuilding, for telegraph poles, and railroad ties. In its structure it resembles spruce. The larches are

deciduous trees, occasionally covering considerable areas, but usually scattered among other conifers.

62. Tamarack (Larix americana) (Hackmatack): Medium-sized tree, often covering swamps, in which case it is smaller and of poor quality. Maine to Minnesota, and southward to Pennsylvania.

63. Tamarack (L. occidentalis): Large-sized trees, scattered, locally abundant. Washington and Oregon to Montana.

PINE

64. Very variable, very light and soft in "soft" pine, such as white pine; of medium weight to heavy and quite hard in "hard" pine, of which longleaf or Georgia pine is the extreme form. Usually it is stiff, quite strong, of even texture, and more or less resinous. The sapwood is yellowish white; the heartwood, orange brown. Pine shrinks moderately, seasons rapidly and without much injury; it works easily; is never too hard to nail (unlike oak or hickory); it is mostly quite durable, and if well seasoned is not subject to the attacks of boring insects. The heavier the wood the darker, stronger, and harder it is, and the more it shrinks and checks. Pine is used more extensively than any other kind of wood. It is the principal wood in common carpentry, as well as in all heavy construction, bridges, trestles, etc. It is also used in almost every other wood industry, for spars, masts, planks, and timbers in shipbuilding, in car and wagon construction, in cooperage, for crates and boxes, in furniture work, for toys and patterns, railway ties, water pipes, excelsior, etc. Pines are usually large trees with few branches, the straight, cylindrical, useful stem forming by far the greatest part of the tree; they occur gregariously, forming vast forests, a fact which greatly facilitates their exploitation. Of the many special terms applied to pine as lumber, denoting sometimes differences in quality, the following deserve attention:—

"White pine," "pumpkin pine," "soft pine," in the Eastern markets refer to the wood of the white pine (Pinus strobus), and on the Pacific Coast to that of the sugar pine (P. lambertiana).

"Yellow pine" is applied in the trade to all the Southern lumber pines; in the Northeast it is also applied to the pitch pine (P. rigida); in the West it refers mostly to bull pine (P. ponderosa).

"Yellow longleaf pine," "Georgia pine," chiefly used in advertisement, refers to longleaf pine (P. palustris).

"Hard pine" is a common term in carpentry, and applies to everything except white pine.

"Pitch pine" includes all Southern pines and also the true pitch pine (P. rigida), but is mostly applied, especially in foreign markets, to the wood of the longleaf pine (P. palustris).

For the great variety of confusing local names applied to the Southern pines in their homes, part of which have been adopted in the markets of the Atlantic

seaboard, see report of Chief Division of Forestry, for 1891, page 212, etc., and also the list below:—

a. **Soft Pines.**

65. White Pine (Pinus strobus): Large to very large sized tree; for the last fifty years the most important timber tree of the Union, furnishing the best quality of soft pine. Minnesota, Wisconsin, Michigan, New England, along the Alleghanies to Georgia.

66. Sugar Pine (Pinus lambertiana): A very large tree, together with Abies concolor forming extensive forests; important lumber tree. Oregon and California.

67. White Pine (Pinus monticola): A large tree, at home in Montana, Idaho, and the Pacific States; most common and locally used in northern Idaho.

68. White Pine (Pinus flexilis): A small tree, forming mountain forests of considerable extent and locally used; eastern Rocky Mountain slopes; Montana to New Mexico.

b. **Hard Pines.**

69. Longleaf Pine (Pinus palustris) (Georgia pine, yellow pine, long straw pine, etc.): Large tree; forms extensive forests and furnishes the hardest and strongest pine lumber in the market. Coast region from North Carolina to Texas.

70. Bull Pine (Pinus ponderosa) (yellow pine): Medium to very large sized tree, forming extensive forests in Pacific and Rocky Mountain regions; furnishes most of the hard pine of the West; sapwood wide; wood very variable.

71. Loblolly Pine (Pinus taeda) (slash pine, old field pine, rosemary pine, sap pine, short straw pine, etc.): Large sized tree, forms extensive forests; wider ringed, coarser, lighter, softer with more sapwood, than the longleaf pine, but the two often confounded. This is the common lumber pine from Virginia to South Carolina, and is found extensively in Arkansas and Texas. Southern States; Virgina to Texas and Arkansas.

72. Norway Pine (Pinus resinosa): Large sized tree, never forming forests, usually scattered or in small groves, together with white pine; largely sapwood and hence not durable. Minnesota to Michigan; also in New England to Pennsylvania.

73. Shortleaf Pine (Pinus echinata) (slash pine, Carolina pine, yellow pine, old field pine, etc.): Resembles loblolly pine; often approaches in its wood the Norway pine. The common lumber pine of Missouri and Arkansas. North Carolina to Texas and Missouri.

74. Cuban Pine (Pinus cubensis) (slash pine, swamp pine, bastard pine, meadow pine): Resembles longleaf pine, but commonly has wider sapwood and coarser grain; does not enter the markets to any great extent. Along the coast from South Carolina to Louisiana.

75. Bull Pine (Pinus jeffreyi) (black pine): Large-sized tree, wood resembling bull pine (P. ponderosa); used locally in California, replacing P. ponderosa at high altitudes.

The following are small to medium sized pines, not commonly offered as lumber in the market; used locally for timber, ties, etc.:—

76. Black Pine (Pinus murrayana) (lodge-pole pine, tamarack): Rocky Mountains and Pacific regions.

77. Pitch Pine (Pinus rigida): Along the coast from New York to Georgia and along the mountains to Kentucky.

78. Jersey Pine (Pinus inops) (scrub pine): As before.

79. Gray Pine (Pinus banksiana) (scrub pine): Maine, Vermont, and Michigan to Minnesota.

REDWOOD (See Cedar)

SPRUCE

80. Resembles soft pine, is light, very soft, stiff, moderately strong, less resinous than pine; has no distinct heartwood, and is of whitish color. Used like soft pine, but also employed as resonance wood and preferred for paper pulp. Spruces, like pines, form extensive forests; they are more frugal, thrive on thinner soils, and bear more shade, but usually require a more humid climate. "Black" and "white spruce," as applied by lumbermen, usually refer to narrow and wide ringed forms of the black spruce (Picea nigra).

81. Black Spruce (Picea nigra): Medium-sized tree, forms extensive forests in northeastern United States and in British America; occurs scattered or in groves, especially in low lands throughout the Northern pineries. Important lumber tree in eastern United States. Maine to Minnesota, British America, and on the Alleghanies to North Carolina.

82. White Spruce (Picea alba): Generally associated with the preceding; most abundant along streams and lakes, grows largest in Montana, and forms the most important tree of the subarctic forest of British America. Northern United States, from Maine to Minnesota, also from Montana to Pacific, British America.

83. White Spruce (Picea engelmanni): Medium to large sized tree, forming extensive forests at elevations from 5000 to 10,000 feet above sea level; resembles the preceding, but occupies a different station. A very important timber tree in the central and southern parts of the Rocky Mountains. Rocky Mountains from Mexico to Montana.

84. Tide-land Spruce (Picea sitchensis): A large-sized tree, forming an extensive coast-belt forest. Along the seacoast from Alaska to Central California.

BASTARD SPRUCE

85. Spruce or fir in name, but resembling hard pine or larch in the appearance, quality, and uses of its wood.

86. Douglas Spruce (Pseudotsuga douglasii) (yellow fir, red fir, Oregon pine): One of the most important trees of the western United States; grows very large in the Pacific States, to fair size in all parts of the mountains, in Colorado up to about 10,000 feet above sea level; forms extensive forests, often of pure growth. Wood very variable, usually coarse-grained and heavy, with very pronounced summer wood, hard and strong ("red" fir), but often fine-grained and light ("yellow" fir). It replaces hard pine and is especially suited to heavy construction. From the plains to the Pacific Ocean; from Mexico to British America.

TAMARACK (See Larch)

YEW

87. Wood heavy, hard, extremely stiff and strong, of fine texture with a pale yellow sapwood, and an orange red heart; seasons well and is quite durable. Yew is extensively used for archery, bows, turner's ware, etc. The yews form no forests, but occur scattered with other conifers.

88. Yew (Taxus brevifolia): A small to medium sized tree of the Pacific region.

B.—Broad-leaved Woods (Hardwoods)

89. Woods of complex and very variable structure and therefore differing widely in quality, behavior, and consequently in applicability to the arts.

ASH

90. Wood heavy, hard, strong, stiff, quite tough, not durable in contact with soil, straight grained, rough on the split surface and coarse in texture. The wood shrinks moderately, seasons with little injury, stands well, and takes a good polish. In carpentry ash is used for finishing lumber, stairways, panels, etc.; it is used in shipbuilding, in the construction of cars, wagons, carriages, etc., in the manufacture of farm implements, machinery, and especially of furniture of all kinds, and also for harness work; for barrels, baskets, oars, tool handles, hoops, clothespins, and toys. The trees of the several species of ash are rapid growers, of small to medium height with stout trunks; they form no forests, but occur scattered in almost all our broad-leaved forests.

91. White Ash (Fraxinus americana): Medium, sometimes large sized tree. Basin of the Ohio, but found from Maine to Minnesota and Texas.

92. Red Ash (Fraxinus pubescens). Small-sized tree. North Atlantic States, but extends to the Mississippi.

93. Black Ash (Fraxinus sambucifolia) (hoop ash, ground ash): Medium-sized tree, very common. Maine to Minnesota, and southward to Virginia and Arkansas.

94. Blue Ash (Fraxinus quadrangulata): Small to medium sized. Indiana and Illinois; occurs from Michigan to Minnesota and southward to Alabama.

95. Green Ash (Fraxinus viridis): Small-sized tree. New York to the Rocky Mountains, and southward to Florida and Arizona.

96. Oregon Ash (Fraxinus oregana): Medium-sized tree. Western Washington to California.

ASPEN (See Poplar)

BASSWOOD

97. Basswood (Tilia americana) (lime tree, American linden, lin, bee tree): Wood light, soft, stiff but not strong, of fine texture and white to light brown color. The wood shrinks considerably in drying works and stands well; it is used in carpentry, in the manufacture of furniture and wooden ware, both turned and carved, in cooperage, for toys, also for paneling of car and carriage bodies. Medium to large sized tree common in all Northern broad-leaved forests; found throughout the eastern United States.

98. White Basswood (Tilia heterophylla): A small-sized tree most abundant in the Alleghany region.

BEECH

99. Beech (Fagus ferruginea): Wood heavy, hard, stiff, strong, of rather coarse texture, white to light brown, not durable in the ground, and subject to the inroads of boring insects; it shrinks and checks considerably in drying, works and stands well and takes a good polish. Used for furniture, in turnery, for handles, lasts, etc. Abroad it is very extensively employed by the carpenter, millwright, and wagon maker, in turnery as well as wood carving. The beech is a medium-sized tree, common, sometimes forming forests; most abundant in the Ohio and Mississipi basin, but found from Maine to Wisconsin and southward to Florida.

BIRCH

100. Wood heavy, hard, strong, of fine texture; sapwood whitish, heartwood in shades of brown with red and yellow; very handsome, with satiny luster, equaling cherry. The wood shrinks considerably in drying, works and stands well and takes a good polish, but is not durable if exposed. Birch is used for finishing lumber in building, in the manufacture of furniture, in wood turnery, for spools, boxes, wooden shoes, etc., for shoe lasts and pegs for wagon hubs, ox yokes, etc., also in wood carving. The birches are medium-sized trees, form extensive forests northward, and occur scattered in all broad-leaved forests of the eastern United States.

101. Cherry Birch (Betula lenta) (black birch, sweet birch, mahogany birch): Medium-sized tree; very common. Maine to Michigan and to Tennessee.

102. Yellow Birch (Betula lutea) (gray birch): Medium-sized tree; common. Maine to Minnesota and southward to Tennessee.

103. Red Birch (Betula nigra) (river birch): Small to medium sized tree; very common; lighter and less valuable than the preceding. New England to Texas and Missouri.

104. Canoe Birch (Betula papyrifera) (white birch, paper birch): Generally a small tree; common, forming forests; wood of good quality but lighter. All along

the northern boundary of United States and northward, from the Atlantic to the Pacific.

BLACK WALNUT (See Walnut)

BLUE BEECH

105. Blue Beech (Carpinus caroliniana) (hornbeam, water beech, ironwood): Wood very heavy, hard, strong, very stiff, of rather fine texture and white color; not durable in the ground; shrinks and checks greatly, but works and stands well. Used chiefly in turnery for tool handles, etc. Abroad, much used by mill and wheel wrights. A small tree, largest in the Southwest, but found in nearly all parts of the eastern United States.

BOIS D'ARC (See Osage Orange)

BUCKEYE—HORSE-CHESTNUT

106. Wood light, soft, not strong, often quite tough, of fine and uniform texture and creamy white color. It shrinks considerably, but works and stands well. Used for woodenware, artificial limbs, paper pulp, and locally also for building lumber. Small-sized trees, scattered.

107. Ohio Buckeye (Æsculus glabra) (fetid buckeye): Alleghanies, Pennsylvania to Indian Territory.

108. Sweet Buckeye (Æsculus flava): Alleghanies, Pennsylvania to Texas.

BUTTERNUT

109. Butternut (Juglans cinerea) (white walnut): Wood very similar to black walnut, but light, quite soft, not strong and of light brown color. Used chiefly for finishing lumber, cabinetwork, and cooperage. Medium-sized tree, largest and most common in the Ohio basin; Maine to Minnesota and southward to Georgia and Alabama.

CATALPA

110. Catalpa (Catalpa speciosa): Wood light, soft, not strong, brittle, durable, of coarse texture and brown color; used for ties and posts, but well suited for a great variety of uses. Medium-sized tree; lower basin of the Ohio River, locally common. Extensively planted, and therefore promising to become of some importance.

CHERRY

111. Cherry (Prunus serotina): Wood heavy, hard, strong, of fine texture; sapwood yellowish white, heartwood reddish to brown. The wood shrinks considerably in drying, works and stands well, takes a good polish, and is much esteemed for its beauty. Cherry is chiefly used as a decorative finishing lumber for buildings, cars, and boats, also for furniture and in turnery. It is becoming too costly for many purposes for which it is naturally well suited. The lumber-furnishing cherry of this country, the wild black cherry (Prunus serotina), is a small to medium-sized tree, scattered through many of the broad-leaved woods of the western slope of the Alleghanies, but found from Michigan to Florida and west to Texas. Other species of this genus as well as the hawthorns (Crataegus) and

wild apple (Pyrus) are not commonly offered in the market. Their wood is of the same character as cherry, often even finer, but in small dimensions.

CHESTNUT

112. Chestnut (Castanea vulgaris var. americana): Wood light, moderately soft, stiff, not strong, of coarse texture; the sapwood light, the heartwood darker brown. It shrinks and checks considerably in drying, works easily, stands well, and is very durable. Used in cabinetwork, cooperage, for railway ties, telegraph poles, and locally in heavy construction. Medium-sized tree, very common in the Alleghanies, occurs from Maine to Michigan and southward to Alabama.

113. Chinquapin (Castanea pumila): A small-sized tree, with wood slightly heavier but otherwise similar to the preceding; most common in Arkansas, but with nearly the same range as the chestnut.

114. Chinquapin (Castanopsis chrysophylla): A medium-sized tree of the western ranges of California and Oregon.

COFFEE TREE

115. Coffee Tree (Gymnocladus canadensis) (coffee nut): Wood heavy, hard, strong, very stiff, of coarse texture, durable; the sapwood yellow, the heartwood reddish brown; shrinks and checks considerably in drying; works and stands well and takes a good polish. It is used to a limited extent in cabinetwork. A medium to large sized tree· not common. Pennsylvania to Minnesota and Arkansas.

COTTONWOOD (See Poplar)

CUCUMBER TREE (See Tulip)

ELM

116. Wood heavy, hard, strong, very tough; moderately durable in contact with the soil; commonly crossgrained, difficult to split and shape, warps, and checks considerably in drying, but stands well if properly handled. The broad sapwood whitish, heart, brown, both with shades of gray and red; on split surface rough; texture coarse to fine; capable of high polish. Elm is used in the construction of cars, wagons, etc., in boat and ship building, for agricultural implements and machinery; in rough cooperage, saddlery and harness work, but particularly in the manufacture of all kinds of furniture, where the beautiful figures, especially those of the tangential or bastard section, are just beginning to be duly appreciated. The elms are medium to large sized trees, of fairly rapid growth, with stout trunk, form no forests of pure growth, but are found scattered in all the broad-leaved woods of our country, sometimes forming a considerable portion of the arborescent growth.

117. White Elm (Ulmus americana) (American elm, water elm): Medium to large sized tree, common. Maine to Minnesota, southward to Florida and Texas.

118. Rock Elm (Ulmus racemosa) (cork elm, hickory elm, white elm, cliff elm): Medium to large sized tree. Michigan, Ohio, from Vermont to Iowa, southward to Kentucky.

119. Red Elm (Ulmus fulva) (slippery elm, moose elm): Small-sized tree, found chiefly along water courses. New York to Minnesota, and southward to Florida and Texas.

120. Cedar Elm (Ulmus crassifolia): Small-sized tree, quite common. Arkansas and Texas.

121. Winged Elm (Ulmus alata) (wahoo): Small-sized tree, locally quite common. Arkansas, Missouri, and eastern Virginia.

GUM

122. This general term refers to two kinds of wood usually distinguished as sweet or red gum, and sour, black, or tupelo gum, the former being a relative of the witch-hazel, the latter belonging to the dogwood family.

123. Tupelo (Nyssa sylvatica) (sour gum, black gum): Maine to Michigan, and southward to Florida and Texas. Wood heavy, hard, strong, tough, of fine texture, frequently crossgrained, of yellowish or grayish white color, hard to split and work, troublesome in seasoning, warps and checks considerably, and is not durable if exposed; used for wagon hubs, wooden ware, handles, wooden shoes, etc. Medium to large sized trees, with straight, clear trunks; locally quite abundant, but never forming forests of pure growth.

124. Tupelo Gum (Nyssa uniflora) (cotton gum): Lower Mississippi basin, northward to Illinois and eastward to Virginia, otherwise like preceding species.

125. Sweet Gum (Liquidambar styraciflua) (red gum, liquidambar, bilsted): Wood rather heavy, rather soft, quite stiff and strong, tough, commonly crossgrained, of fine texture; the broad sapwood whitish, the heartwood reddish brown; the wood shrinks and warps considerably, but does not check badly, stands well when fully seasoned, and takes good polish. Sweet gum is used in carpentry, in the manufacture of furniture, for cut veneer, for wooden plates, plaques, baskets, etc., also for wagon hubs, hat blocks, etc. A large-sized tree, very abundant, often the principal tree in the swampy parts of the bottoms of the lower Mississippi Valley; occurs from New York to Texas and from Indiana to Florida.

HACKBERRY

126. Hackberry (Celtis occidentalis) (sugarberry): A handsome wood, heavy, hard, strong, quite tough, of moderately fine texture, and greenish or yellowish white color; shrinks moderately, works well, and takes a good polish. So far but little used in the manufacture of furniture. Medium to large sized tree, locally quite common, largest in the lower Mississippi Valley; occurs in nearly all parts of the eastern United States.

HICKORY

127. Wood very heavy, hard, and strong, proverbially tough, of rather coarse texture, smooth and of straight grain. The broad sapwood white, the heart reddish nut-brown. It dries slowly, shrinks and checks considerably; is not durable in the ground, or if exposed, and especially the sapwood, is always subject to the inroads of boring insects. Hickory excels as carriage and wagon stock, but is

also extensively used in the manufacture of implements and machinery, for tool handles, timber pins, for harness work, and cooperage. The hickories are tall trees with slender stems, never form forests, occasionaly small groves, but usually occur scattered among other broad-leaved trees in suitable localities. The following species all contribute more or less to the hickory of the markets:—

128. Shagbark Hickory (Hicoria ovata) (shellbark hickory). A medium to large sized tree, quite common; the favorite among hickories; best developed in the Ohio and Mississippi basins; from Lake Ontario to Texas, Minnesota to Florida.

129. Mocker Nut Hickory (Hicoria alba) (black hickory, bull and black nut, big bud, and white-heart hickory): A medium to large sized tree, with the same range as the foregoing; common, especially in the South.

130. Pignut Hickory (Hicoria glabra) (brown hickory, black hickory, switch-bud hickory): Medium to large sized tree, abundant; all eastern United States.

131. Bitternut Hickory (Hicoria minima) (swamp hickory): A medium-sized tree, favoring wet localities, with the same range as the preceding.

132. Pecan (Hicoria pecan) (Illinois nut): A large tree, very common in the fertile bottoms of the Western streams. Indiana to Nebraska and southward to Louisiana and Texas.

HOLLY

133. Holly (Ilex opaca): Wood of medium weight, hard, strong, tough, of fine texture and white color; works and stands well, used for cabinet work and turnery. A small tree, most abundant in the lower Mississippi Valley and Gulf States, but occurring eastward to Massachusetts and north to Indiana.

HORSE-CHESTNUT (See Buckeye)

IRONWOOD (See Blue Beech)

LOCUST

This name applies to both of the following:

134. Black Locust (Robinia pseudacacia) (black locust, yellow locust): Wood very heavy, hard, strong, and tough, of coarse texture, very durable in contact with the soil, shrinks considerably and suffers in seasoning; the very narrow sapwood yellowish, the heartwood brown, with shades of red and green. Used for wagon hubs, treenails or pins, but especially for ties, posts, etc. Abroad it is much used for furniture and farm implements and also in turnery. Small to medium sized tree, at home in the Alleghanies, extensively planted, especially in the West.

135. Honey Locust (Gleditschia triacanthos) (black locust, sweet locust, three-thorned acacia): Wood heavy, hard, strong, tough, of coarse texture, susceptible of a good polish, the narrow sapwood yellow, the heartwood brownish red. So far but little appreciated except for fencing and fuel; used to some extent for wagon hubs and in rough construction. A medium-sized tree, found from Pennsylvania to Nebraska and southward to Florida and Texas; locally quite abundant.

MAGNOLIA (See Tulip Wood)

MAPLE

136. Wood heavy, hard, strong, stiff, and tough, fine texture, frequently wavy-grained, this giving rise to "curly" and "blister" figures; not durable in the ground or otherwise exposed. Maple is creamy white, with shades of light brown in the heart; shrinks moderately, seasons, works, and stands well, wears smoothly, and takes a fine polish. The wood is used for ceiling, flooring, paneling, stairway, and other finishing lumber in house, ship, and car construction; it is used for the keels of boats and ships, in the manufacture of implements and machinery, but especially for furniture, where entire chamber sets of maple rival those of oak. Maple is also used for shoe lasts and other form blocks, for shoe pegs, for piano actions, for school apparatus, for wood type in show-bill printing, tool handles, in wood carving, turnery, and scroll work. The maples are medium-sized trees, of fairly rapid growth; sometimes form forests and frequently constitute a large proportion of the arborescent growth.

137. Sugar Maple (Acer saccharum) (hard maple, rock maple): Medium to large sized tree, very common, forms considerable forests. Maine to Minnesota, abundant, with birch, in parts of the pineries; southward to northern Florida; most abundant in the region of the Great Lakes.

138. Red Maple (Acer rubrum) (swamp or water maple): Medium-sized tree. Like the preceding, but scattered along water courses and other moist localities.

139. Silver Maple (Acer saccharinum) (soft maple, silver maple): Medium sized, common; wood lighter, softer, inferior to hard maple, and usually offered in small quantities and held separate in the market. Valley of the Ohio, but occurs from Maine to Dakota and southward to Florida.

140. Broad-leafed Maple (Acer macrophyllum): Medium-sized tree, forms considerable forests, and like the preceding has a lighter, softer, and less valuable wood. Pacific coast.

MULBERRY

141. Red Mulberry (Morus rubra): Wood moderately heavy, hard, strong, rather tough, of coarse texture, durable; sapwood whitish, heart yellow to orange brown; shrinks and checks considerably in drying; works and stands well. Used in cooperage and locally in shipbuilding and in the manufacture of farm implements. A small-sized tree, common in the Ohio and Mississippi Valleys, but widely distributed in the eastern United States.

OAK

142. Wood very variable, usually very heavy and hard, very strong and tough, porous, and of coarse texture; the sapwood whitish, the heart "oak" brown to reddish brown. It shrinks and checks badly, giving trouble in seasoning, but stands well, is durable, and little subject to attacks of insects. Oak is used for many purposes: in shipbuilding, for heavy construction, in common carpentry, in furniture, car, and wagon work, cooperage, turnery, and even in wood carving;

also in the manufacture of all kinds of farm implements, wooden mill machinery, for piles and wharves, railway ties, etc. The oaks are medium to large sized trees, forming the predominant part of a large portion of our broad-leaved forests, so that these are generally "oak forests" though they always contain a considerable proportion of other kinds of trees. Three well-marked kinds, white, red, and live oak, are distinguished and kept separate in the market. Of the two principal kinds white oak is the stronger, tougher, less porous, and more durable. Red oak is usually of coarser texture, more porous, often brittle, less durable, and even more troublesome in seasoning than white oak. In carpentry and furniture work red oak brings about the same price at present as white oak. The red oaks everywhere accompany the white oaks, and, like the latter, are usually represented by several species in any given locality. Live oak, once largely employed in shipbuilding, possesses all the good qualities (except that of size) of white oak, even to a greater degree. It is one of the heaviest, hardest, and most durable building timbers of this country; in structure it resembles the red oaks, but is much less porous.

143. **White Oak** (Quercus alba): Medium to large sized tree, common in the Eastern States, Ohio and Mississippi Valleys; occurs throughout eastern United States.

144. **Bur Oak** (Quercus macrocarpa) (mossy-cup oak, over-cup oak): Large-sized tree, locally abundant, common. Bottoms west of Mississippi; range farther west than preceding.

145. **Swamp White Oak** (Quercus bicolor): Large-sized tree, common. Most abundant in the Lake States, but with range as in white oak.

146. **Yellow Oak** (Quercus prinoides) (chestnut oak, chinquapin oak): Medium-sized tree. Southern Alleghanies, eastward to Massachusetts.

147. **Basket Oak** (Quercus michauxii) (cow oak): Large-sized tree, locally abundant; lower Mississippi and eastward to Delaware.

148. **Over-cup Oak** (Quercus lyrata) (swamp white oak, swamp post oak): Medium to large sized tree, rather restricted; ranges as in the preceding.

149. **Post Oak** (Quercus obtusiloba) (iron oak): Medium to large sized tree. Arkansas to Texas, eastward to New England and northward to Michigan.

150. **White Oak** (Quercus durandii): Medium to small sized tree. Texas, eastward to Alabama.

151. **White Oak** (Quercus garryana): Medium to large sized tree. Washington to California.

152. **White Oak** (Quercus lobata): Medium to large sized tree; largest oak on the Pacific Coast; California.

153. **Red Oak** (Quercus rubra) (black oak): Medium to large sized tree; common in all parts of its range. Maine to Minnesota, and southward to the Gulf.

154. Black Oak (Quercus tinctoria) (yellow oak): Medium to large sized tree; very common in the Southern States, but occurring north as far as Minnesota, and eastward to Maine.

155. Spanish Oak (Quercus falcata) (red oak): Medium-sized tree, common in the South Atlantic and Gulf region, but found from Texas to New York, and north to Missouri and Kentucky.

156. Scarlet Oak (Quercus coccinea): Medium to large sized tree; best developed in the lower basin of the Ohio, but found from Maine to Missouri, and from Minnesota to Florida.

157. Pin Oak (Quercus palustris) (swamp Spanish oak, water oak): Medium to large sized tree, common along borders of streams and swamps. Arkansas to Wisconsin, and eastward to the Alleghanies.

158. Willow Oak (Quercus phellos (peach oak): Small to medium sized tree. New York to Texas, and northward to Kentucky.

159. Water Oak (Quercus aquatica) (duck oak, possum oak, punk oak): Medium to large sized tree, of extremely rapid growth. Eastern Gulf States, eastward to Delaware, and northward to Missouri and Kentucky.

160. Live Oak (Quercus virens): Small-sized tree, scattered along the coast from Virginia to Texas.

161. Live Oak (Quercus chrysolepis) (maul oak, Valparaiso oak): Medium-sized tree; California.

OSAGE ORANGE

162. Osage Orange (Maclura aurantiaca) (Bois d'Arc): Wood very heavy, exceedingly hard, strong, not tough, of moderately coarse texture, and very durable; sapwood yellow, heart brown on the end, yellow on longitudinal faces, soon turning grayish brown if exposed; it shrinks considerably in drying, but once dry it stands unusually well. Formerly much used for wheel stock in the dry regions of Texas; otherwise employed for posts, railway ties, etc. Seems too little appreciated; it is well suited for turned ware and especially for wood carving. A small-sized tree, of fairly rapid growth, scattered through the rich bottoms of Arkansas and Texas.

PERSIMMON

163. Persimmon (Diospyros virginiana): Wood very heavy and hard, strong and tough; resembles hickory, but is of finer texture; the broad sapwood cream color, the heart black; used in turnery for shuttles, plane stocks, shoe lasts, etc. Small to medium sized tree, common and best developed in the lower Ohio Valley, but occurs from New York to Texas and Missouri.

POPLAR AND COTTONWOOD (See also Tulip Wood)

164. Wood light, very soft, not strong, of fine texture, and whitish, grayish, to yellowish color, usually with a satiny luster. The wood shrinks moderately (some

crossgrained forms warp excessively) but checks little; is easily worked but is not durable. Used as building and furniture lumber, in cooperage for sugar and flour barrels, for crates and boxes (especially cracker boxes), for woodenware and paper pulp.

165. Cottonwood (Populus monilifera): Large-sized tree; forms considerable forests along many of the Western streams, and furnishes most of the cottonwood of the market. Mississippi Valley and west; New England to the Rocky Mountains.

166. Balsam (Populus balsamifera) (balm of Gilead): Medium to large sized tree; common all along the northern boundary of the United States.

167. Black Cottonwood (Populus trichocarpa): The largest deciduous tree of Washington; very common. Northern Rocky Mountains and Pacific region.

168. Cottonwood (Populus fremontii var. wislizeni): Medium to large sized tree, common. Texas to California.

169. Poplar (Populus grandidentata): Medium-sized tree, chiefly used for pulp. Maine to Minnesota and southward along the Alleghanies.

170. Aspen (Populus tremuloides): Small to medium sized tree, often forming extensive forests and covering burned areas. Maine to Washington and northward, south in the Western mountains to California and New Mexico.

RED GUM (See Gum)

SASSAFRAS

171. Sassafras (Sassafras sassafras): Wood light, soft, not strong, brittle, of coarse texture, durable; sapwood yellow, heart orange brown. Used in cooperage, for skiffs, fencing, etc. Medium-sized tree, largest in the lower Mississippi Valley, from New England to Texas and from Michigan to Florida.

SOUR GUM (See Gum)

SWEET GUM (See Gum)

SYCAMORE

172. Sycamore (Platanus occidentalis) (buttonwood, buttonball tree, water beech): Wood moderately heavy, quite hard, stiff, strong, tough, usually crossgrained, of coarse texture, and white to light brown color; the wood is hard to split and work, shrinks moderately, warps and checks considerably, but stands well. It is used extensively for drawers, backs, bottoms, etc., in cabinetwork, for tobacco boxes, in cooperage, and also for finishing lumber, where it has too long been underrated. A large tree, of rapid growth, common and largest in the Ohio and Mississippi Valleys, at home in nearly all parts of the eastern United States. The California species—

173. Platanus racemosa resembles in its wood the Eastern form.

TULIP WOOD

174. Tulip Tree (Liriodendron tulipifera) (yellow poplar, white wood): Wood quite variable in weight, usually light, soft, stiff but not strong, of fine texture, and yellowish color; the wood shrinks considerably, but seasons without much injury; works and stands remarkably well. Used for siding for paneling and finishing lumber in house, car, and ship building, for sideboards, and panels of wagons and carriages; also in the manufacture of furniture, implements and machinery, for pump logs, and almost every kind of common wooden ware, boxes, shelving, drawers, etc. An ideal wood for the carver and toy man. A large tree, does not form forests, but is quite common, especially in the Ohio basin; occurs from New England to Missouri and southward to Florida.

175. Cucumber Tree (Magnolia acuminata): A medium-sized tree, most common in the southern Alleghanies, but distributed from New York to Arkansas, southward to Alabama and northward to Illinois. Resembling, and probably confounded with, tulip wood in the markets.

TUPELO (See Gum)

WALNUT

176. Black Walnut (Juglans nigra): Wood heavy, hard, strong, of coarse texture; the narrow sapwood whitish, the heartwood chocolate brown. The wood shrinks moderately in drying, works and stands well, takes a good polish, is quite handsome, and has been for a long time the favorite cabinet wood in this country. Walnut, formerly used even for fencing, has become too costly for ordinary uses, and is today employed largely as a veneer, for inside finish and cabinetwork; also in turnery, for gunstocks, etc. Black walnut is a large tree, with stout trunk, of rapid growth, and was formerly quite abundant throughout the Alleghany region, occurring from New England to Texas, and from Michigan to Florida.

WHITE WALNUT (See Butternut)

WHITE WOOD (See Tulip, and also Basswood)

YELLOW POPLAR (See Tulip)

METALS

177. Iron is the most useful and widely distributed of all metals. It is essential to life, being found in the green part of plants and in the blood of animals. It forms the basis of the whole building industry, and, if it were to disappear, most industries would be ruined. It has been used since long before the birth of Christ, but the many difficulties encountered in removing it from impurities have caused progress in iron working to be slow until recent years.

Pure iron is very difficult to obtain and all forms of iron and steel now used commercially contain impurities. Iron pure enough

for commercial use is obtained through a long process. Iron is found in all countries and makes up one-twentieth part of the earth's crust. The mining of iron ore and the making of iron and steel have become one of the most important industries. In this respect the United States leads the world with an output of 35,000,000 tons per year. Great Britain ranks next with 14,000,000 tons. The chief iron ore producing states of the Union rank as follows: Minnesota, Alabama, Michigan, Pennsylvania, New York.

178. **Iron Ore.**—Iron is never found pure in the earth, but is mixed with rocks and other minerals, in which form it is called "iron ore." The ore is removed from the iron mines and taken to great smelting works. Huge furnaces are filled from the top with a mixture of fuel, ore and limestone. The fuel is lighted and blasts of hot air are forced through the furnace. The fuel burns violently and the iron ore and limestone soon melt into a fluid mass. The iron being heaviest sinks to the bottom while most of the other materials, including limestone, float. The molten iron is drawn off and flows either into a series of small ditches made in sand, or else into a "pig moulding" machine. Here it cools and is then ready to be shipped to the markets. In this form it is known as pig iron.

179. **Pig Iron.**—Pig iron is used in making all other forms of iron or steel. As pig iron, it contains several per cent, often from 5 to 6, of impurities. There are different grades of pig iron, depending upon the kind of impurities and the manner in which they are combined. When the chief impurity is carbon, mixed with the iron, but not combined, the metal is fairly tough and can be machined. Such metal is known as **grey iron.** When the carbon is combined with the iron, the metal becomes so hard and brittle it cannot be machined, and is called **white iron.** A third quality of pig iron lies between these extremes and is called **mottled iron.** In general, pig iron is hard and brittle and may be melted and poured unchanged to form castings of parts that will not receive hard usage.

180. **Cast Iron.**—Pig iron used to form castings is called cast iron. The castings are hard and brittle, and contain a high percentage of impurities. The nature of cast iron varies, depending upon the impurities remaining in it. The grade of iron used in a casting depends upon the nature of the casting desired. Usually a grade of iron that will fill the mould without much shrinkage in cooling is desired. Stove

parts, hot air registers, water and sewer mains, steam radiators, school desk frames, etc., are made of cast iron.

181. **Malleable Cast Iron.**—Many small articles which were formerly made of cast iron have been much improved by making them from "malleable cast iron," sometimes called "semi-steel." Articles of this kind are made from iron that is given a long annealing at a high temperature before being cast. By this treatment, the metal is rendered much more pliable than ordinary cast iron. Properly prepared, malleable cast iron may be bent double without cracking. Such iron is more resistant to shock than ordinary cast iron. Pipe fittings are nearly always made of such material. Many cheap tools, especially hammers, are made of malleable cast iron.

182. **Steel.**—Steel is made by refining pig iron. It is cast into ingots and finally rolled or forged into the finished form. It varies from hard steel, containing one per cent or more of carbon, and having a tensile strength of over 100,000 pounds per square inch, to soft steel, containing less than 0.1 per cent carbon, and having a tensile strength of about 55,000 pounds per square inch. The former may be hardened or tempered by different processes and is used for keen cutting articles, such as razors, knives, etc. The latter is not materially hardened by tempering, but can be readily welded, worked and formed cold, like wrought iron. Between these two extremes there is a wide range of products, differing chiefly in their carbon content. **Crucible steel** is usually employed for surgical instruments, watch springs, etc., where a very high grade steel is required. It is produced by heating wrought iron in a crucible with charcoal until the proper carbon content is obtained, eliminating the slag, and casting into ingots, which are forged into the desired shape. Structural steel as used in building construction is usually medium carbon steel (about 0.3 per cent carbon), having an ultimate strength of about 70,000 pounds per square inch.

183. **Wrought Iron.**—Wrought iron is produced by melting pig iron out of contact with the fuel. As the impurities are removed, in the form of gases, slag and cinders, the molten metal becomes pasty and is stirred or "puddled" by machinery. Wrought iron has a fibrous structure, and is soft and malleable. It can be welded, and is not materially hardened by tempering.

Since low-carbon steel has most of the characteristics of wrought iron and can be produced at much less cost, it has largely replaced wrought iron. However, wrought iron is still used for certain purposes, such as stay bolts in boiler construction, where it is believed its fibrous structure enables it to stand alternating strains better than ordinary steel.

184. **Galvanized Iron.**—The term galvanized iron is applied to any form of iron or steel coated with zinc. The zinc may be applied by the "hot dip" process, the "electrolytic" process or the "sherardizing" process. It is necessary that the iron be cleaned with acid before the zinc is applied.

Hot-Dip Process. In the hot-dip process the iron or steel is passed through a bath of molten zinc, which leaves a coating of zinc on the outside. The thickness of the zinc coating depends on the temperature of the bath, the speed of passing, and the extent to which the metal is wiped after coating. Sheet metal, wire and pipe are usually coated by the hot dip process.

Electrolytic Process. The electrolytic process is usually applied to small, irregular shaped articles. As the name implies, the coating is obtained by depositing the zinc from a solution by means of an electric current.

Sherardizing Process. The sherardizing process is also applied to small, irregular shaped articles. It is done by heating articles together with powdered zinc in an iron drum. The zinc is deposited on the iron so as to form a firm coating conforming sharply to the original line of the object being coated.

A zinc coating forms an excellent protection to iron, since the iron will not rust while the coating remains. Galvanized iron can be soldered, but sharp bending will crack the zinc coating.

Copper

185. **Copper** is one of the first metals of which we find any record in history. Numerous objects made of copper by the ancients more than three thousand years ago are still in existence. The Michigan copper deposits appear to have been used by the American Indians. Copper ornaments, bracelets, rings and anklets, implements, knives and axes made from copper, have been found in Indian graves and ruins of their dwellings. Copper is hard, of a reddish color and is

usually found mixed with other minerals. It is one of the most useful of metals. Copper is widely distributed, but is found in paying quantities in few localities. Montana, Michigan and Arizona furnish half the world's supply.

Although both copper and tin are soft, a mixture or alloy of these metals is hard. Cannon are made of an alloy of ninety parts copper and ten parts tin. Copper is used in making bronze and brass. It was once in great demand for sheathing the keels of vessels, but has been supplanted largely by iron and the substitution of copper paint. Copper is used for plumbing and in roofing. Copper wire is strong and is one of the best conductors of electricity.

The annual consumption of copper has increased faster than that of any other metal, and it is now estimated that the United States alone uses one billion pounds per year.

Brass and Bronze

186. **Brass** is an alloy of copper and zinc and is yellow in color. **Bronze** is an alloy of copper and tin and has a brownish color. Other minerals, such as lead, iron, manganese, nickel, phosphorus, etc., are present frequently in small amounts, and affect the quality of these alloys. Brass is striking in appearance and is much used for ornamental work, such as door plates, lighting fixtures, fastenings, and turned work. Brass is very suitable for making castings and shrinks but little on cooling. Much metal that passes for brass is really bronze. Bronze was known to the ancients; in fact the use of bronze preceded that of iron and steel. They found it very satisfactory for making swords, axes and other edged tools. For some purposes, bronze is superior to iron. It is very tough and will not rust. Bronze used for bells contains as high as 25 per cent tin, but for most purposes bronze is 70 to 90 per cent copper. Alloys used for making statuary vary greatly in composition. Some statues are made of almost pure brass, others contain from 1 to 25 per cent of tin, zinc, or sometimes lead. An alloy of copper and aluminum, called **aluminum-bronze** has great tensile strength.

Lead

187. **Lead** is a heavy, pliable and inelastic metal. It has a bright silver color, but is rapidly tarnished to a dark grey by the action of the atmosphere. Lead is 11.37 times as heavy as water, and a cubic

foot of it weighs 710 pounds. It seldom occurs pure in nature. Lead is a constituent of alloys, as solder, type metal, babbit metal and pewter. It is extensively used in making white lead. Next in importance is its use in lead pipe and sheet lead for plumbing. Large quantities of lead are used in the making of shot and other ammunition. Lead is also used in the manufacture of glass.

The United States leads the world in the production of lead. Lead ore is found in the mountains from Maine to Georgia, but not in very large quantities. All of the western states produce lead.

Zinc

188. **Zinc** is a bluish white metal with a brilliant luster. It is obtained by heating zinc ores in a closed vessel. The vapor is cooled into a liquid and cast into plates called "spelter." A second heating and collection of vapor gives zinc, free from other matter.

In the United States zinc ores are found in association with lead throughout the Missouri lead district. Joplin, Missouri, is the center of American production. Next to the mines of the Mississippi region, the zinc ores of Sussex County, New Jersey, are the most important. Zinc is also obtained in Colorado and Wisconsin.

Since zinc does not rust readily, it is desirable for articles used in damp places. Zinc is much used for galvanizing iron. Imitations of gold used for gliding are made of an alloy of zinc and copper. Zinc is frequently used with other metals to form alloys, both brass and bronze being alloys of this kind. Zinc roofing is not uncommon. Being a poor conductor of heat, sheets of zinc are excellent protection against heat from stoves and furnaces. Eyelets made from zinc for use on clothing will not rust and discolor the cloth. Zinc coated nails and tacks are used where it is necessary to guard against rust. Covers for fruit jars, linings for washing tanks, the facing of washboards, and metal weather strips are common uses of this metal.

Tin

189. **Tin** is a very useful metal. It is nearly as white and lustrous as silver, and may be rolled into exceedingly thin sheets known as tin-foil. Tin is one of the lighter metals and is but 7.3 times heavier than water. It is not affected by the atmosphere or ordinary heat conditions, except that exposure to the weather destroys its lustre. It is used extensively for kitchen utensils, such as pans, cups, plates

and similar articles. A considerable portion of the tin supply goes into the manufacture of bronze.

A thin sheet of iron or steel, coated or plated with tin, is called tin plate. The coating is applied to prevent rusting of the iron. Tin plate is used for roofing and spouting. Tin could not be used alone because it is too soft and easily bent. The iron gives strength while the coating of tin adds lustre and preserves the iron.

The United States annually imports 95,000,000 pounds of tin from England and the East Indies. The value of tin imported is more than that of any other imported metal. Half the world's supply of tin is consumed in the United States.

Tin is found in paying quantities in only a few places. It is plentiful in the southwestern part of Great Britain. Wales is a producing field which has in recent years fallen off to a considerable extent. The East Indies furnish the largest quantity. In continental Europe there are profitable mines. Important mines exist in Bolivia. Alaska is known to have tin deposits, also North Carolina, South Dakota, Texas and California. To a large extent these deposits still await development.

Aluminum

190. Aluminum is separated from clay by electrolysis. Beds of clay suitable for the purpose occur in Georgia, Alabama and Arkansas. It is one of the most important and lightest of metals. It is silvery white and about as hard as zinc. Aluminum is about one-third as heavy as iron and a little more than one-fourth as heavy as copper. In tensile strength it excels all other metals except iron and copper, yet it can be readily hammered into sheets and drawn into wire. It is a good conductor of electricity.

Its uses are constantly increasing. One of its important uses is in the manufacture of steel, as the addition of an almost inperceptible amount of aluminum, say five-thousandths of one per cent, eliminates air holes from the steel. It is also used in the manufacture of kitchen utensils, for which it is well suited, being light and durable. It does not rust, nor chip and is not readily acted upon by acids. Aluminum has to some extent displaced copper as a conductor of electricity. Thin sheets of it are used in place of tin-foil. Also the metal is used for hairpins, tnimbles, bands for canes and umbrellas, combs, and backs for brushes.

There are numerous alloys of aluminum, as aluminum bronze, aluminum gold, and other alloys made by special processes and used in boat construction and automobiles, and for the framework of aeroplanes.

The production of aluminum in the United States increased from 1.5 tons in 1886 to 23,062 tons in 1911. The average annual production is now about 40,000 tons.

Nickel

191. Nickel is a hard, white metal with a slightly yellowish tinge. It is capable of a high polish and resists oxidation. It is more brittle than cast iron, but when mixed with small amounts of magnesium or phosphorous, it can be hammered or rolled into thin sheets.

Small quantities of nickel are found in the Alleghany, Cascade and Rocky Mountains. Lancaster Gap, Pennsylvania, and Sunbury, Ontario, are the only localities in America in which nickel is obtainable in considerable quantities. New Caledonia, in Oceania, is the source of a large supply.

Nickel is extensively used in electro-plating and in the manufacture of inexpensive metallic articles. Nickel is used in several alloys, as nickel copper and zinc and nickel steel. The "nickel" coin or five-cent piece is made from an alloy of nickel and copper.

Stone, Clay and Glass Products

Lime

192. Lime is a very common building material. It is made from various products such as limestone, marble, chalk, etc.

In the manufacture of lime, limestone is heated in a kiln or furnace, and the heat changes the limestone to lime, called caustic or quick lime.

When lime is exposed to air or water it **slakes**, that is, it absorbs water. In plaster and mortar, lime is supplied with water and allowed to slake before it is used. In making plaster, slaked lime is mixed with sand and hair, the former to add bulk and hardness and the latter to give toughness.

Lime, being one of the cheapest of caustic or alkaline substances, has many applications. It is used in the manufacture of bleaching

powder, in tanning, in purifying coal gas, in refining sugar, in making certain varieties of glass, and in making fungicides, such as lime-sulphur and Bordeaux mixture.

Cement

193. Natural cement made by volcanic action was used by the Romans before the time of Christ, but it was not until 1824 that a prepared mixture was patented. The prepared mixture was called "Portland Cement," which name it still retains.

Cement consists of certain proportions of lime, clay and sand. At present it is manufactured by two processes, the wet and the dry.

In the dry process, rock containing these substances in the proper proportions is crushed into small pieces, dried in kilns and ground to powder. This powder is burned to a clinker in a kiln. The clinker is ground to a fine powder, which is packed in sacks or barrels for the market. When clay and limestone need to be mixed before burning, the wet process is used. Each is ground separately; then they are wet and mixed in the proper proportions. The mixture is made into bricks, which when dry, are burned, and again ground to a powder, as in the dry process. Cement is usually sold in bags containing 94 pounds or approximately one cubic foot.

Portland cement, after being mixed with water to a stiff paste, becomes a solid mass within a few hours. It gains strength for an indefinite period, usually not attaining its maximum strength before one year. When mixed with sand and water, it forms a mortar which also becomes very hard and durable. A cube of cement mortar composed of one part cement to three parts sand, by volume, one month after molding should bear a load of one ton or more per square inch.

In massive work, less cement is used without much sacrifice of strength by mixing gravel or crushed stone in the mortar. A mixture of this kind is called **concrete.** It is in this form that cement enters most largely into building construction. The three things entering into concrete construction are: (1) The **matrix,** or binding agent, which is the cement; (2) the **aggregate,** which consists of such materials as broken stone, sand or gravel; (3) **water.**

Concrete is of greyish color. It "sets" in a few hours, but does not reach its full strength for at least a year. Its strength and durability depend upon the quality and nature of the materials used and the care with which they are mixed.

Concrete is high in compressive strength but low in tensile strength and is unsuited for the construction of load-carrying beams and floor slabs, which are supported only at their ends. To overcome this defect, the concrete in such construction is cast around steel rods, which become a part of the beam or slab. The steel supplies the tensile strength which is lacking in the concrete. The combination, called **reinforced concrete**, is suited to almost any type of construction in which strength and rigidity are essential.

Sand and Gravel

194. **Sand** consists of fine particles of stone mixed loosely in a mass. It is formed by the breaking down of rock. Many miles of river beds and ocean beaches are covered with sand. It is also found in strata under the surface of the earth.

Some sands contain the ores of iron, gold, platinum, silver and other metals, which are occasionally present in paying quantities. Sand often presents beautiful colors, given to it by some mineral which it contains, but is usually a dull yellow. The uses of sand in industry are numerous. It is used as an abrasive, as a polishing material, in molding, glassmaking, plastering, concrete work, filtering, etc.

195. **Gravel** is a term applied to a mixture of coarse sand and small stones of varying sizes. Its chief use is in road making and as an aggregate in concrete making. It is used to some extent as a filtering agent.

Building Stone

196. There are numerous varieties of stone used in construction work. In fact, any stone of such a character as to give it long life and resistance to pressure, is suitable for building purposes. Stone was one of the early building materials utilized by man. Structures built of stone before the birth of Christ are still standing, and buildings of this material that have stood for several centuries are in good condition. Stone used for building purposes is known in the trade as **building stone.** The kinds commonly used in this country are granite, limestone, marble and sandstone. In addition, onyx, marble and slate are used in finishing interiors.

In selecting the stone for use in buildings or other structures, the archiect is governed by the following considerations:

(1) Strength required; (2) Durability; (3) Convenience of access; (4) Expense of working; (5) Architectural effect.

197. Granite is the strongest and most durable stone. Its use is generally specified for the foundations of heavy buildings, for piers, and for the walls of large public buildings.

198. Limestone differs greatly in quality in different parts of the country. Some is unfit for building purposes, but much of it is of good quality. It is used for foundations, walls, bridges, and as an aggregate in concrete making.

199. Marble is a limestone that has become close grained under the influence of heat and pressure in nature. Marble will take a high polish and varies in color from pure white to black. It is largely used in the construction of public buildings and statuary.

200. Sandstone is rock composed of sand held together by some binding agent. When grains of sand are bound together and stained by iron, a brown sandstone is formed. This stone is used extensively for the fronts of buildings. It is more brittle than limestone and will not withstand so great a pressure. Grindstones are made from fine grained sandstone.

201. Slate.—The best known slates quarried in this country are found in eastern New York, Vermont, Pennsylvania and other localities in the northern Alleghany region. Slate is used extensively for roofing, sinks, mantels and inside finishings.

202. Onyx is used for clock cases, bureau and table tops, mantels, vases and inside finishings of public buildings. There are two varieties of onyx, one a kind of quartz closely allied to agate. It varies in color from white to brown, red or black. The other is a variety of marble, called also oriental alabaster. The world's choicest supply comes from Algeria.

Brick

203. Brickmaking is said to have been carried on by the Babylonians and Egyptians, in the valleys of the Euphrates and the Nile, where both timber and stone were lacking. Sun dried brick four thousand years old have been found in a state of excellent preservation. Straw was used in these early brick as a binding material just as hair or

other substance is used in lime plaster. For brickmaking, clay must be free from limestone and must contain little iron. If sand is not already present in the clay, sufficient sand should be added to make a mixture of one part sand to two parts clay.

Brick are made by three principal methods. They may be made by pressing soft clay by hand into wooden molds, or by means of a machine closely imitating this process. This process is called the soft-clay method, because the brick thus molded contain a large percentage of water. The brick so made are very porous and they cannot be made dense even by hard burning. This, however, does not detract from their durability. The texture of soft molded brick is pleasing and together with the characteristic red color, contrasts pleasantly with the green of the landscape. The early colonial residences and churches of Virginia afford many fine examples of buildings made from hand-molded brick.

Another method of brickmaking consists in forcing stiff clay through the die or opening of a machine somewhat resembling the ordinary meat or sausage grinder. This machine forms a column of clay the width of which corresponds to the length of the brick and the thickness to the width. By means of wires stretched between frames, this column is then cut into brick. The amount of water used in this process is very much less than in the first method, and it is called the stiff-clay method. This process is used especially in the manufacture of brick that are to form the outside of a wall. Brick so made are marketed under various trade names, such as "tapestry," "devonshire," or "rug" brick.

In spite of their greater density, it is more essential that stiff-molded brick be burned hard, than brick made by the first mentioned process. Very porous, underburned, stiff-molded brick are more likely to crumble under the action of frost than soft-molded brick.

Brick are also made by grinding the raw material to a moist powder and shaping it into the desired form by means of a powerful press. This method is called the dry-press process.

It results in a well shaped and finished brick, which is compact and dense in appearance. The amount of water used in this process is very small. If more water is used the process is called the semi-dry process and makes a denser brick. Both dry and semi-dry pressed brick were in large demand up to ten years ago, but in recent years the stiff-clay products have largely replaced them. The mechanical

perfection and finish of the dry-pressed brick does not appeal to the modern architect, who objects to their smooth regularity and prefers the rough texture and variety afforded by other kinds of brick.

The quality of building brick must be considered from several standpoints. It must be kept in mind that the requirements are more severe in the case of front brick than for the cheaper kind used for backing up walls. For the latter purpose, comparatively soft and porous brick, which would not be suitable for exposure to the weather, may be used.

In addition to the use of brick in building construction, they are also used in paving streets and roads. To make brick hard enough to withstand the wear of heavy traffic, lime is added to the clay and sand and they are burned at a very high temperature. Such brick are sometimes sold under the name of "vitrified brick," and are of a glassy appearance. The introduction of steel frames into buildings has greatly increased the use of brick. Brick are also used for foundations, for lining sewers, tunnels, chimneys and cisterns.

Over 30,000,000 brick are produced annually in the United States. The brickmaking industry is quite widely distributed throughout the country, and hardly a town of importance is without a brickmaking plant. However, the great centers of the industry are along the Hudson River from Troy to New York City, in Philadelphia County, Pa., and in Cook County, Ill.

Terra Cotta

204. Terra Cotta is a kind of earthenware made from clay and is of finer quality than ordinary brick. It is used in making architectural decorations, pottery, garden vases, flower pots, monuments, fountains, mantels, chimney pieces and similar objects. It may be produced in any color, but the typical color is a pinkish hue. Other colors vary from a deep red to a light cream. In manufacture, after the clays are refined and kneaded, they are pressed into molds. After being taken from the molds they are worked over by hand, if necessary, and then allowed to dry, after which the pieces are baked in large kilns.

Among the ancients, terra cotta was very extensively used. The Greeks employed it in making roof tiles, gutters, house ornaments, statues, vases, tombs and coffins. Modern architects do not use terra cotta as much as stone, marble, brick or granite. In some large cities

the fronts of tall buildings are occasionally covered with white glazed terra cotta. Such a surfacing has the advantage of being very easily kept clean.

Tile

205. **Tile** are thin pieces of burned clay. They are made in various shapes and are adapted to various purposes, as coverings for roofs, walls, furnace linings and flooring. In the form of hollow tiles they are used for drainage and in the construction of the inner walls of buildings.

206. **Wall Tile.**—The well known glazed tile come under this head and are used in mantels, bathroom and kitchen walls. They are made in a variety of colors and textures both glossy and dull. Wall tile are made from a very fine grade of clay and sometimes from the same materials as porcelain. Beautiful effects may be obtained by using tile of different colors artistically arranged.

207. **Floor Tile.**—Two kinds of floor tile are used. The vitreous tile are very hard and glassy and practically non-absorbent. They are often used in the form of mosaics. The semi-vitreous tile are usually put down in the form of large tile. The second class is often made from a red burning clay and is known as quarry tile. They have a deep red color and lend a pleasing decorative effect.

208. **Roofing Tile.**—Roofing tile make a pleasing style of roofing material, lend an artistic effect to the building and are durable and satisfactory. They are so made as to possess the necessary weather resisting qualities.

209. **Hollow Tile.**—There are two general purposes for which hollow tile are made,—building construction and drainage. In modern building construction, hollow tile are used especially for inner walls and floor bases. They afford a dead air space in construction which tends to eliminate dampness and render buildings sound proof. Modern methods of steel frame construction lend themselves readily to the use of hollow tile.

Drainage tile are made in a great variety of sizes and materials, from the common clay ditch tile to large size sewer tile. The latter are made of glazed material, to resist the attacks of moisture and freezing.

Pottery

210. Clay containing the proper amount of moisture can be worked into almost any shape, and then hardened by heat. These processes form the basis of the art of pottery making which has been practiced since earliest times.

Some of the essential steps in the process of making pottery are: (1) Shaping; (2) Drying; (3) Firing; (4) Glazing. Pottery may be divided into three general classes. (1) **Earthenware:** This is the cheapest kind of pottery. It is soft, easily scratched and is very absorbent. The common flower pot is an example. (2) **Stoneware:** It is a hard, vitrified product. Ordinary table ware is an example. (3) **Porcelain:** Porcelain is a white translucent ware. It varies in grades all the way from the cheaper kitchen porcelain to the best of china.

Some of the largest American potteries are in Cincinnati, Jersey City and on Long Island. The value of our annual output of pottery is about $35,000,000.

Glass

211. **Glass** is not found like gold, silver or coal, but is made by melting together certain materials. The essential materials are: silicon, in the form of pure, clean sand; crushed quartz or flint; an alkali, as soda or potash; and either lime, in the form of chalk or limestone, or else lead. Sand is the chief material and glass may almost be called melted sand.

In the manufacture of window glass, the materials mentioned are mixed thoroughly and subjected to intense heat, almost three thousand degrees Fahrenheit. After being melted, the materials are allowed to cool until a molten pasty mass is formed. Then a workman, called a glass blower, dips one end of a long, hollow metal pipe into the soft, hot glass and twists it around until a lump weighing about twenty pounds sticks to the end of the pipe. By blowing through the pipe while keeping the glass hot, a long bubble of cylindrical shape is formed. This cylinder of glass is afterwards cut open at the ends and slit along the side. Then it is put into a furnace and heated until the cylinder slowly spreads open and rests flat upon the floor of the furnace. This sheet is then sent through an annealing furnace to be properly toughened for use. Afterward, it is cut into

commercial sizes. This process has been improved so that much of the above work is done by machinery.

Plate glass is made by a special process and is the most expensive form of window glass. After being melted, the glass is poured on to a flat casting table. The moulten glass is rolled to uniform thickness by huge rollers, after which it is annealed. Annealing is necessary to make glass tough and strong. After annealing, both sides are ground with sand and polished with emery and rouge.

To make wire plate glass, a piece of wire netting is placed between two plates of glass while they are soft. Wire plate glass is strong and is used in basement windows and skylights.

Most table glassware is made by pressing the glass to shape in iron molds which contain the design of the articles to be made. After being taken from the mould or press, the article is annealed and polished. Such articles are a great deal less expensive than those made by the blowing process. The more expensive tableware is made by blowing. **Cut glass** is made by being molded or blown to shape with a plain surface. The design is then ground into the glass by means of a wheel of soft steel, copper or sandstone. Through special processes other forms of glass are produced, as chipped glass, art glass, etc. Glass may be spun very fine and woven into a kind of cloth, or the fine fibers may be used for brushes which are adapted to special purposes.

The United States imports annually over $8,000,000 worth of glass and its export is valued at nearly $4,000,000. There are about 400 glass factories in the United States. Our annual production is about $80,000,000.

Preserving and Finishing Materials

Paints

212. **Paint** is used to decorate and preserve wood, metal and other materials. Paint is a mixture of solid and liquid which gives an opaque coating. It is applied, either by brushing, spraying or dipping. These coatings dry on the surface forming a thin film which prevents moisture and air from reaching the material painted.

The two essential ingredients in paint are the **pigment**, which is

the coloring mater, and the **vehicle,** which is the liquid used to carry the pigment in suspension.

Many materials are used in making paints. Mention is made below of the most important ones.

213. Linseed oil, which is the oil obtained from flax seed, is the most important of the dying oils. See Oils, page 224. This oil is sold either in the form of raw linseed oil or boiled linseed oil. The raw oil varies from a pale straw color to dark amber and has a mild odor. It frequently contains considerable sediment or cloudy matter. Raw linseed oil when spread in thin coats and exposed to the air and light will generally dry to a fairly hard film in from two to six days. Refined linseed oil is oil that has been treated to remove the cloudy sediment and at the same time some of the color.

When heated to a sufficiently high temperature, linseed oil undergoes decomposition. Boiled linseed oil is linseed oil that has been heated somewhat below its decomposition point with lead and manganese. Some of the metals go into solution and give the oil the property of drying more rapidly than raw oil. However, in most paints where raw oil is used, a certain amount of "drier" is added which hastens the drying. There is little, if any, difference between the results obtained with raw and boiled oil, if the proper addition of drier to raw oil is made.

214. Driers.—Certain metals, especially lead and manganese, when in drying oils cause the drying to take place more rapidly. Most driers are in liquid form and are known as "driers," "oil driers," "Japan driers," or simply as "Japans." They consist either of solutions of lead or manganese salts, of acids of linseed oil or of resins, or of mixtures of such materials dissolved in a liquid that evaporates readily such as turpentine or light petroleum oil.

215. Volatile Thinners.—Turpentine, which is the liquid made by distilling the resin of pine trees, is the most important volatile thinner used. It has excellent solvent, evaporating, and flatting properties and is preferred for general paint and varnish operations. It is expensive and in many cases the cheaper volatile liquids such as light mineral oils, variously known as benzine, naphtha, petroleum spirit, and turpentine substitute, may be successfully used.

216. A paint pigment furnishes the color and should consist of very finely ground particles. It should form as nearly as possible an

opaque coating; and should have no injurious action on the vehicle, or the surface on which the paint is applied. It should not settle too rapidly out of suspension in the vehicle.

217. Paints vary according to the character of the use for which they are intended. Besides the common outside paints which are used as protective and decorative coverings for buildings, there are other special paints designed for certain uses. **"Wall paints"** came into use in response to a demand for an interior paint, to be used on walls, which could be washed. **Enamel paints** are made with a varnish vehicle. In other respects they differ little from oil paints. They are used for interior or protected work only. They dry quickly and leave a gloss finish. **Red-lead paint** is used for protecting iron and steel. This paint is often mixed on the job and is much used by plumbers. **Bronze paints** are frequently used for coating metal surfaces where a decorative effect is desired, such as steam radiators and exposed pipes. They consist chiefly of finely ground metal in a vehicle of celluloid varnish (banana oil). **Water paints.—Whitewash** is the best example of water paint. It makes a sanitary coating, and is much used on cellars, stables, etc. Other forms of water paints have as their bases, whiting, clay, silicates, etc., instead of lime, as in whitewash. They are known as calcimines, or by special trade names, and are tinted various colors, in which form they are generally used for inside wall decoration.

Oils

218. All oils are lighter than water and are almost insoluble in it. They are, however, soluble in alcohol and in some other substances. According to the sources from which they are obtained, oils are classified as vegetable, animal or mineral. According to their chemical action, they are classified as **fixed** and **volatile.**

219. **Fixed oils** are oils that do not evaporate rapidly. They are of both animal and vegetable origin. Among the most valuable fixed oils are those obtained from certain kinds of fish. These are known as marine or fish oils. Seeds of plants are also important sources of fixed oils, among which may be mentioned flax seed oil, cotton seed oil, castor oil and corn oil. Animal oils such as lard and tallow are fixed oils. Heat is usually applied when extracting both animal and vegetable fixed oils, because by its use greater quantities of oil can be obtained. Oil may be extracted from seeds by pressure without

heat. Oil obtained in this manner is said to be "cold pressed" and is of better quality than hot pressed oil.

220. **Volatile oils** are those that evaporate readily on exposure to the air. They are obtained from plant and mineral sources. When dissolved in alcohol, volatile oils are extensively used in the manufacture of perfumery, and some of them are used for medicinal purposes.

221. **Drying oils** belong to the class of fixed oils and are extensively used in making paints. They absorb oxygen when exposed to the air and form an elastic solid substance. If four plates of glass are coated, one with a thin film of water, another with gasoline, another with a heavy mineral oil, and another with linseed oil, and all exposed to the air for several days, the water and gasoline will evaporate and leave the plates in practically the same condition they were before applying the liquids. The plate covered with the heavy mineral oil will be left greasy, while the plate covered with the linseed oil will also have a coating on it, but this will be found to have set into a firm, hard, varnish-like film. If this is tried with other oils, it will be found that some of them, as olive oil, will behave very much like mineral oils; that is, there will be only a slight tendency toward the formation of a varnish-like coating. Other oils such as corn or soybean oil will behave in a manner similar to linseed oil. Oils that leave a varnish-like coating are called drying oils.

Varnishes

222. A **varnish** differs from a paint in that varnish is transparent while paint is opaque. Varnishes are used to give a protective and brilliant transparent coating to various surfaces as metal-work, wood, paint and paper. A good varnish should form a thin, transparent and firmly adherent layer or film on the surface over which it is spread. It should dry hard in a reasonable length of time, and yet remain sufficiently elastic not to crack or check. The materials used almost entirely to form the body of varnishes are the drying oils and resinous substances, the chief of which are the copals, lac, damar, amber, sandarac and resin.

For certain forms of varnish, the drying oils themselves act as the solvent of the resins, but in other cases volatile oils are employed as solvents. These solvents are chiefly alcohol, ether, benzine and turpentine. According to the solvents employed, varnishes are divided into three classes: spirit, turpentine, and oil.

Shellac varnish is a solution of gum shellac in alcohol. Damar varnish is a solution of damar resin in turpentine. Oil varnishes are not made by the simple solution of varnish resins in solvents, for the varnish resins are not soluble in their original condition. However, the varnish maker by heating and by the addition of drying oils and drying metals produces a substance which can be thinned with a volatile thinner to make oil varnishes.

Long-oil varnishes are those that contain a large amount of drying oil (40 to 60 per cent drying oil and from 5 to 20 per cent resins), and produce coats which, while not so hard, are more resistant to the weather than those produced by short-oil varnishes. Short-oil varnishes are those that contain a relatively large amount of varnish resins (25 to 40 per cent drying oil and 20 to 25 per cent resin). A spar varnish is a long-oil varnish, while a rubbing varnish is a short-oil varnish. There are many special kinds of varnishes used in the trades, also a wide variety of colored varnishes which are adapted to special uses.

Shellacs

223. Shellac is extensively used in finishing wood and is the most useful of the spirit varnishes. Shellac is made from lac, or gumlac, a resinous substance excreted by a very small insect common to Siam, Bengal and Assam. The young insects, or larvae, feed on the sap of certain trees and give off a resinous substance which covers their bodies and forms a scale on the twigs sometimes a half-inch in thickness. The twigs are broken off by the natives and dried in the sun and in this form the product is known as stick-lac. When dry the twigs are pounded to remove the resinous substance, which is washed to remove coloring matter and other impurities. The product is then known as seed-lac. The seed-lac is put into bags and hung over a slow fire. As the resinous substance melts, it is squeezed from the bag and allowed to flow over a smooth surface where it cools in thin layers known as shell-lac or shellac. Commercially, due to its yellow color, it is called orange shellac. White shellac is made from orange shellac by bleaching.

Stains

224. Stains may be classed as very thin, penetrating paints. Their object is to change the color of the material to which they are applied.

According to their composition, stains may be divided into four general classes. These classes are not entirely distinct, as stain manufacturers mix the materials to get certain results. The classes are: (1) water stains; (2) oil stains; (3) spirit stains; (4) stains due to chemical action. Each of the above classes of stains has some good quality which belongs to it alone. In specifying the kind of stain to be used, there is no better guide than a knowledge of the nature of the wood on which it is to be used, the requirements of the job and the conditions under which the finish must be applied.

225. **Water Stains.**—Water stains penetrate deeply, give a very clear tone, free from muddy effects, and do not obscure the grain. They are inexpensive and brushes used in them are easily cleaned. The disadvantages are that they raise the grain of the wood and will not penetrate the surface of any wood that is not clean and dry.

226. **Oil Stains.**—Oil stains have the good quality of being easily applied; that is, they do not show brush laps, and it is easy to get uniform color. They do not raise the grain of wood. The chief disadvantages are that they do not give a clear tone and to some extent obscure the grain. Neither do these stains penetrate very deeply into wood.

227. **Spirit Stains.**—Spirit stains have practically disappeared from the market. They are high in cost and difficult to apply. Some spirit stains are sold, but they are more or less mixed with other mediums which tend to make them easier to work. One advantage of a spirit stain is its ability to penetrate through surface conditions and give a clear color.

228. **Stains due to chemical action.**—The color effect of certain chemicals upon wood is pleasing. For instance, the action of ammonia gives an aged effect to the wood either when applied in solution directly to the wood or when wood is exposed to its fumes. The color is produced by chemical action and depends much upon the character of the wood to which it is applied. Other chemicals that produce pleasing effects when applied to wood are, potassium bichromate and acetate of iron. This method of staining is cheap, very effective on certain woods, and much used, especially in furniture manufacturing.

229. Many different kinds of so-called varnish stains are sold under trade names. They are usually made from low grade varnish to which color has been added. They are not stains in the sense that

color is imparted to the wood, for they dry quickly upon the surface leaving the wood unchanged. **Shingle stains** have come to be much used in modern architecture. They are similar to paints, but are made much thinner and usually contain creosote as part of the vehicle, which aids in preserving the wood. While shingle stains are used primarily to preserve wood, pigments are added and a variety of colors produced to harmonize with the exterior decorations of buildings.

Wax

230. Wax was formerly made by the old English wood finishers, of one part melted beeswax and one part turpentine. After standing several days the wax was ready to use, and by rubbing, produced a polish with a soft, agreeable lustre. At present, commercial wax contains more or less of other products to make it less expensive, and while it gives good results, it does not excel the old English formula.

A wax finish has a good appearance, but is easily marred. However, it can be quickly restored by rubbing on more wax. The ease with which it may be applied recommends it to amateur woodworkers. While it looks well and the effect is beautiful, if properly done, it will not stand wetting and requires constant care.

Fillers

231. Fillers are used for closing the pores in open grained wood, such as oak and ash. They are usually made from some finely ground filling substance in suspension in alcohol or a volatile oil. Fillers are sometimes made of such substances as whiting, plaster of Paris and corn starch. It has been found that these substances shrink in drying and do not serve the purpose well. The object in filling is to create a non-absorbent base for the finish. The fillers most often used are made of finely ground silex mixed with linseed oil, turpentine or other oil. Silex, because of the peculiar needle-like shape of the particles, is especially suitable as a filler, as it works well into the wood, holds its place and is non-absorbent.

Wood may also be filled by successive coats of shellac, each carefully rubbed down until the pores are filled and a good base built up. This is an expensive and time-taking operation.

Fillers may be purchased in two forms, liquid and paste. Liquid fillers are usually low grade varnishes mixed so as to dry quickly. Other liquid fillers are combinations of glue with a filler. Liquid

fillers work best on close grained woods. Paste fillers are combinations of suitable filling materials with a very small amount of oil or turpentine or a turpentine substitute, and are often colored to match the color of the wood.

Creosote

232. Most decay in timber is caused by two classes of minute organisms called bacteria and fungi. Decay is checked by treating the wood with a substance that is poisonous to these organisms. There are many which may be used for this purpose, but few are suited for commercial use. One of the first essentials for a successful wood preservative is that its effectiveness is not destroyed by varying weather conditions. The best material so far found is **creosote**, a product distilled from coal tar. It is used for the preservation of posts, silos, railroad ties, and parts of ships. There are three methods of application: the brush method, the pressure method, and the open-tank method. According to the United States government tests, the length of life of an untreated loblolly pine fence post is about two years. By a creosote treatment its life is increased to twenty years. A railroad tie of the same wood untreated will last five years. When treated with creosote, it will last twelve years.

Pliable Materials

233. **Rubber.**—Rubber comes from certain vines and trees which grow most abundantly in hot, moist lands. These plants grow in the heart of the African continent, in India, Siam, Burma, Ceylon, Borneo, Java, and, under cultivation, in Mexico and Central America.

While it is possible to obtain rubber from many trees, shrubs and vines common to the countries lying between the tropics of Cancer and Capricorn, yet most rubber is obtained from the milky juice or latex of great silver-grey trees, which are known as rubber trees. These trees are tapped to allow the juice to escape. In this juice float minute globules of rubber, which, when allowed to stand, rise to the top, like cream. The water is evaporated, leaving pure rubber. The pure rubber, together with a small amount of sulphur, is heated, which changes the rubber so that it remains flexible in cold weather and does not soften in hot weather. This process is called "vulcanizing" and was patented by Charles Goodyear in 1844. This is one of the greatest discoveries ever made in the rubber industry. Hard

rubber is called vulcanite or ebony and is made by using more sulphur and greater heat. The color of rubber depends upon the treatment it receives in the process of manufacture.

Our great-grandfathers used practically no rubber, yet its growth in value has been so rapid that man could scarcely do without it to-day. The uses of rubber are so numerous that they cannot all be given space here. Rubber is found as a part of many household articles and clothing. It furnishes the doctor with valuable equipment and the tradesman with various kinds of mechanical appliances. Rubber is indispensable in the making of automobile tires and in the manufacture of aeroplanes. It is employed in electrical machinery and is used in a liquid form as a cement and varnish.

Leather

234. The skins of animals have been used for clothing since the earliest times, and at first were preserved without removing the hair. Centuries later tanning came into use and has been practiced to the present with but slight changes. Pieces of leather discovered in China are said to be more than three thousand years old. Skins preserved with the hair on are called fur. When the fur is removed they are called leather.

The leather industry has become so important that not enough skins are obtainable here to meet all our needs. The United States each year imports thousands of hides of all kinds. In manufacturing shoes, more leather is consumed than in any other industry. The United States makes more leather shoes than any other nation and her people are the best shod people on earth. The value of the footwear manufactured in the United States each year amounts to more than a half billion dollars. Enormous quantities of leather are used for gloves, upholstering, bookbinding, trunks, bags, pocketbooks, etc.

The thickest leather is obtained from the rhinoceros, hippopotamus, elephant and walrus. Horses and cattle furnish thick, strong leather. The pig, calf, goat, kid, sheep, kangaroo, and dog furnish lighter leathers. A very fine quality of leather is made from sealskin.

In preparing leather, it is first necessary to remove the hair, wool or fur from the skin. The hides as they come from the animals are soaked in fresh water to soften and clean them. Next they are

soaked for a few days in water containing lime which loosens the hair. Following this, the hide is placed upon a smooth surface and the hair is scraped off. Then, it is turned over and all particles of flesh are removed. After being washed again in clean water to remove the lime, it is ready for tanning.

The preservation of the skin after the hair has been removed is called tanning. Hides are tanned by three methods: vegetable or organic tanning, chrome tanning, and alum tanning. Vegetable tanning is done by soaking the hides in water and a vegetable material, as oak bark, hemlock bark, sumac leaves or materials of a similar nature. This process requires months, after which the leather is dried, smoothed, dyed and finished according to the use for which it is intended. Vegetable tanning is now used only in the case of heavier hides, such as would be used for shoe soles, harness and belting.

In recent years, by means of chemicals, the most important of which is chromic acid, tanning is done in a very short time. Much of the leather now used in shoes, upholstering, etc., is tanned by the chrome process. This method of tanning is applied largely to lighter skins, as calf, colt, goat and sheep.

Skins are sometimes tanned by using alum, salt, bran and water. The process is called alum tanning. Alum tanning is used frequently for the lighter colored leather, white kid, etc.

Tanned leathers differ, both according to the methods of tanning, and the kind of skins used. Morocco leather is prepared from goat skins. It is so finished that it shows a roughly grained surface. Russia leather is tanned with birch bark. Japanned or "patent" leather has a coat of enamel baked on the surface of the leather which gives it a brilliant polish. Cordovan leather comes from horsehides. Danish leather, used chiefly for gloves, is made by tanning with willow bark. Chamois leather is oil tanned sheep or lamb skin.

235. Artificial Leather.—Many substitutes and imitations of leather have appeared. They are sold under various trade names as "Boston leather," "Pantasote," "Chase leather," "Keratol," "Mule skin" and "Fabrikoid." Artificial leather is generally made by coating cotton cloth with linseed oil, turpentine, lampblack and other ingredients. This is heated and smoothed with pumice stone and another coating applied. After three or four coats have been applied, it is covered with enamel paint and grained.

Textiles

236. Textiles are fabrics or goods manufactured by weaving fibers of the following classes into cloth:

Animal Fibers; as wool, silk, mohair.

Vegetable Fibers; as cotton, flax, jute, hemp.

Mineral Fibers; as abestos, tinsel.

Remanufactured Fibers; as noils, mungo, shoddy, extracts, flocks.

Artificial Fibers; as spun glass, artificial silk, slagwool.

Textile manufacturing has always been one of the leading industries. In the United States the value of the product of all the textile industries, including subsidiary factory output, is exceeded only by that of the iron and steel industry. The textile industry in this country employs nearly one million people and has an annual output valued at almost two billion dollars.

237. Wool and Hair.—Wool is the curly, soft material which forms the coat of such animals as sheep, goats, and alpacas. Wool is a curly, fine, soft fiber covered with very minute scales or notches which distinguish it from other hair. Wool is usually weaker, finer and shorter than any other class of hair. Wool, due to the scales or notches, may be felted, while coarser hair cannot be so treated. Felting is the process of entangling or matting the fibers so the notches cling together, forming a compact material. The material for felt boots and felt hats is made in this manner. Articles could not be made from hair, other than wool, in this way.

Wool is used in the manufacture of thread, yarn, cloth and felted articles.

Hair is used in plastering, upholstering, brushmaking, etc.

With the exception of cotton, wool is the most extensively used of all textile fibers.

The annual wool clip in the United States is about 290,000,000 pounds. Australia ranks first in wool production.

238. Silks.—Silk is the product of the silk worm. After spinning cocoons, the worms are killed by heat and the cocoons are placed in warm water to soften them. The ends from four or five of the cocoons are caught and unwound together to form a thread. This thread is wound into hanks or skeins and sold as raw silk. Silk thread is woven into fabrics. It is used for clothing, draperies, for insulating electric

wires, for fine, strong cords or lines, etc. In the United States there are more than ninety thousand persons employed in manufacturing silk products and the annual value of the products reaches almost $200,000,000.

239. **Artificial Silk.**—Silk consists of almost pure transparent fiber, and as similar material can be made commercially, artificial silk, made from plant fibers, has come into use. It closely resembles silk in most of its properties, but it does not have the wearing qualities of silk. It is usually sold as fiber silk.

240. **Mohair** is a fabric made from the long, silky hair of the Angora goat. It is used for clothing.

241. **Cotton.**—Of all materials made into fabrics, cotton is the most valuable and most extensively used. The cotton crop of the United States each year is worth almost as much as all of the gold and silver mined in five years. From one-half to four-fifths of the human race wear cotton clothing. Man uses two or three times as much cotton as wool. The United States produces the greater part of the world's cotton and furnishes the other nations of the world with the bulk of their raw cotton. Other countries producing large amounts of cotton are Brazil, Egypt, India, and portions of Africa.

Cotton fiber is the white, fluffy covering of the cotton seed and when ripe is of a spiral twisting character, very small and delicate. It is this twist that aids in spinning and in the forming of a strong thread.

There are many varieties of the cotton plant. The two most commonly known are the Sea Island cotton and Upland cotton. The fiber of the Sea Island cotton is the most valuable, being from one and one-half to two and one-half inches long and very silky. It is used in fine clothing and in fabrics where strength is essential, as in automobile tires.

Upland cotton fiber averages about one inch in length and is used largely in making cloth.

While the chief use of cotton is in the manufacturing of clothing, it is used also in making nitro-cellulose, in bedding, in commercial rubber products, etc.

A substitute for cotton fiber has been made from wood pulp. It compares favorably with cotton, both in its properties and the cost of production. However, cotton has a permanent place in the industries.

China grass furnishes a fiber that bids fair to be important, if cheap methods of cleaning the fiber can be devised. Fiber from the pineapple plant is of excellent quality and is used for textile purposes. The high cost of production has so far limited its use.

242. **Linen.**—Linen is obtained from the inner bark of the flax plant. It ranks first in value among the stem fiber crops. If properly treated, flax fiber has an almost silky lustre and is very strong.

In the United States, the manufacture of linen fabrics until 1914 was practically confined to making thread, twine and toweling, but the manufacture of the finer linens has greatly increased since the beginning of the World War. The chief sources of flax are Russia, Holland, Belgium, Ireland, Canada and the United States. Its principal uses are in the manufacture of toweling, sheetings, canvas, handkerchiefs and laces.

243. **Jute.**—Another important plant stem fiber is jute, which is used for twine, burlap, cheap upholstery and binding thread. The last mentioned is used in the manufacture of carpets and rugs. Jute is inexpensive and is used in larger quantities than any other fiber except cotton. Among vegetable fibers it ranks third in importance, being inferior in quality to cotton and flax. This fiber is the product of two closely related tropical plants which grow chiefly in India and the East Indian Islands.

244. **Hemp** is a fiber obtained from the stem of the hemp plant. It is a native of the warmer parts of Asia, but is cultivated in nearly all the countries of Europe and America. Hemp fiber is exceedingly strong and is adapted to the manufacture of ropes and cordage. Twines, carpet thread, sail cloth and coarse grades of woven goods are made from it. Kentucky is one of our chief hemp producing states.

245. **Sisal and Manilla Hemp.—Sisal Hemp** is found in New Mexico, Central America and the West Indies. The fiber is obtained from the thick leaves of the sisal plant. It is much used in making fine rope, bagging and binder twine. It is not so strong as Manila, but of finer quality.

Manila Hemp is obtained in the same manner as sisal, but from a different plant which is common to the Philippine Islands. It makes excellent ropes, cables and binder twine. The finer grades are sometimes woven into cloth.

Mineral Fibers

246. Asbestos.—Asbestos is found in Canada, Italy, Cape Colony, East Russia and Siberia. Asbestos is quarried and crushed in rock breakers. Then it is passed between rollers and graded on a shaking screen where the loosened fibers are sorted. Asbestos is spun into threads, twisted into ropes, woven into fabrics and felted into paper. It will not burn and is used to pack joints, for fire curtains, for insulating pipes and in chemical apparatus.

247. Tinsel.—Tinsel consists of sheets or strips of any glittering metallic substances flattened to the thinness of paper. Tinsel is used in pieces, strips and threads for any purpose in which a sparkling effect is desired without much cost.

Remanufactured Fibers

248. Remanufactured wool permits wool garments to be made at a low price. If no woolen clothing were remade into cloth, the price of wool would be so high that many people could not afford to buy it. The following are the most important materials made from wool waste and reclaimed fabrics.

249. Noils.—In wool combings, the short and defective fibers and knots of wool are called noils. With the exception of length, the noils are of practically the same quality as the wool from which they are taken. Noils are used in making many kinds of woolen articles.

250. Shody and Mungo are woolen goods made from used material. Old cloth and woolen clippings are torn apart or shredded by machinery and the fibers respun into cloth. Shoddy is obtained from flannels, wraps, stockings and all kinds of soft, woolen goods. It has a longer fiber and is more valuable than mungo, which is obtained from hard woven goods. Both shoddy and mungo make low grade cloth.

251. Extract wool is reclaimed from cloth consisting of other material besides wool. After extracting the other materials by a chemical process, the wool is left and may be again used in cloth.

252. Flocks are soft fibers obtained as a by-product in the manufacture of woolen cloth. Flocks vary in value according to the length of the fiber, those having the longest fibers being useful in making low grade cloth.

Artificial Fibers

253. **Artificial fibers** have been made to take the place of both vegetable and animal fibers. In some cases they have proven of value for certain purposes as in the case of fiber silk, already mentioned. Glass wool is made by drawing out molten glass into fine threads. It is used for insulating and packing pipes, etc. Spun glass is made in a similar manner except that the threads are not curly. As yet, it is of small practical value.

Paper

254. The United States leads the world in paper making. The value of the annual output of paper is approximately three hundred million dollars. The wood consumed yearly amounts to about five million cords.

What we term "paper" did not exist, except in China, before the eighth century and was not manufactured in Europe before the twelfth century. In very early times, records were kept on stone or clay tablets, or upon any material which could be cut or scratched. The first material to be used that had any resemblance to paper was papyrus, made from a water plant of the same name and extensively cultivated in ancient times in Egypt. From the twelfth century to the fourteenth, parchment was the ordinary writing material of Europe. Parchment is skin, usually from sheep or goats, so prepared that both sides may be written upon. Parchment being greasy, does not take ink readily, and at the present day is not regarded as a desirable writing material. It is imitated by certain papers called "parchment" paper.

Paper is made from the cell walls of plants and trees. It is possible to make paper from any vegetable material. However, only certain plants are used, as the paper material obtained from some is so small in quantity as not to be commercially profitable and others yield a poor quality. Also, many paper-making materials, such as straw, are available only at certain seasons of the year and are too bulky to permit storing or transporting any distance. A mill to handle such materials would have to stand idle during a portion of the year. It is probable that the utilization of by-products will make it possible and profitable to use many materials for paper that can not be economically used under present methods.

The grey material of which the wasp builds her nest is made from wood and is genuine paper. A boy can make paper by grinding a

piece of spruce or poplar on a wet grindstone until a handful of fiber has been collected. This fiber is then boiled for two or three hours; pounded with a hammer until fine, then thrown into a kettle of hot water and left until the floating fibers form a film. The film may be lifted by means of a sieve or a piece of wire cloth. The film is placed between two pieces of blotting paper and run through a clothes wringer. If the work is properly done, the fine fibers of the wood will felt, forming a sheet of coarse paper. This process is, in the essentials, the plan followed in paper mills.

Abrasives

Corundum and Emery

255. Corundum is a mineral compound. It is believed that the stone was first imported into Europe from India. There are many varieties of corundum, **emery** being a coarse and an impure grade.

Corundum is the hardest and the sharpest mineral known except the diamond. The precious stones, Ruby, Sapphire and Oriental Emerald are perfectly crystalized and highly colored varieties of corundum. Corundum is not only harder than any other mineral generally used for abrasive or grinding purposes, but it possesses great toughness and breaks with sharp, jagged edges, thus giving it durability and continued cutting power.

The terms, emery and corundum, as applied in practice are often used interchangeably. As a rule, an emery wheel for grinding is not cut from the stone, but is built up from finely ground emery held together with cement. Rubber and copper are frequently added to the composition to give toughness. Ground emery, in different degrees of fineness, is also used in making emery paper and emery cloth in the same way that sandpaper is made.

A corundum wheel, properly made and graded, is much superior to a wheel made of emery for grinding purposes. It will not only do more work, but will do it faster.

Carborundum

256. Corborundum is not found in nature, but is a manufactured abrasive. It is not even an imitation of a natural product, but is a new and distinct creation. It is made by mixing in proper proportions, coke, sand, sawdust, and salt, and subjecting them to intense heat in an electric furnace. In about thirty-six hours the mixture

is taken from the furnace in the form of a mass of coarse crystals which when finely ground become dull grey in color. This powder is called carborundum and is used as a polishing material, for making hones, stones for various purposes, and grinding wheels. These products are made in greatly varying degrees of hardness and fineness.

Pumice

257. **Pumice** is a highly porous, light, mineral substance of volcanic origin. It is usually a whitish or clear grey color, and more rarely of a slaty blue or reddish tint. It is highly valued as a polishing material and is used in polishing marble, horn, wood, bone, ivory, etc. Pumice is used either in the form of a built-up stone or powder. Spread upon cloth or paper it is used by dentists, jewelers and others in polishing. It is an ingredient of many tooth powders. Soap makers use it mixed with soap as a scouring agent. It occupies an important place in wood-finishing, being used in this connection to rub down varnish finishes to a smooth, uniform surface. See Art. 122, Sec. 4.

Oil Stones

258. Under the general grouping of "oil stones" there are several different kinds of stones, both natural and artificial. They are used in the industries to sharpen tools and for other abrasive purposes. The natural stone most commonly used is the **Washita stone,** which is quarried in the Ozark mountains. This stone is regarded by many workmen as the best natural stone for general use. It comes in various grades and needs to be carefully selected.

259. **The Arkansas Stone** is finer and harder than the Washita. For this reason it is well adapted to the use of engravers, and wood carvers where a sharper edged tool is necessary than in less delicate work. It is also used for sharpening instruments by surgeons, students of anatomy and biology and others who perform delicate or microscopic work. The extreme firmness of this stone makes it cut slowly, but it is a most excellent sharpening agent.

260. Common sandstones are used also as hones and whetstones, and the best grade is often sold as oil stones. They cut rapidly and are good for ordinary requirements.

261. **India Stones.**—These stones are made by a patented process from a material called alundum. They cut rapidly and are adapted to the use of machinists and woodworkers. India stones come in three grades of grit; fine, medium and coarse.

Sandpaper

262. Paper commonly known as sandpaper is made in degrees of fineness from very fine, called number 000, to very coarse, called number 4. Both coarser and finer papers than these are made for special uses. Sandpaper is made from clean, washed, graded and carefully selected sand which is cemented to tough paper by glue. Emery, glass, corundum and carborundum are glued to paper in the same way as sand and are often referred to as sandpapers. Sandpaper is sold in sheets usually 9 x 11 inches, though the size varies. It is also sold in rolls usually of fifty yards each, in various widths, from 2⅜ inches to 48 inches. The quality of the paper to which the cutting material is applied varies greatly according to the use to which the paper is to be subjected.

Steel Wool

263. Steel Wool.—This is an abrasive adapted especially to cleaning and polishing surfaces that are uneven, as turned, carved or beaded work. It consists of steel shavings, varying in fineness, turned from steel disks. The thin fibers are pliable and so reach every corner and crevice; it is rapid in action and will not gum. It is graded from number 00 to number 3. Number 00 is used for very high finish and fine work and is particularly adapted to rubbing down piano cases. Number 0 is frequently used as a substitute for pumice stone in rubbing down successive coats of varnish. Number 3 is equivalent to number 1½ sandpaper.

Roofing Materials

Shingles

264. Shingles are made from red cedar, cypress and red wood, although pine shingles are also used. Oak shingles were common in early days. Shingles are eighteen inches long and vary in width up to eight inches or more. From three-eighths of an inch thick at one end, they taper to less than one-eighth at the other. Shingles are bunched, with the equivalent of two hundred and fifty singles of four-inch average width to a bunch. In roofing, shingles are usually laid with from four to five inches to the weather; that is, this amount of the shingle is exposed from under the next one overlaping it. With four and one-half inches to the weather, a four-inch shingle will cover

eighteen square inches of exposed surface. A square (100 square feet) will require 800 such shingles.

Metal Roofs

265. In recent years, **metal roofs** have come into quite general use. They are made in a variety of shapes and are well adapted for use on barns, warehouses and similar buildings. They may be laid rapidly, and with proper care will give good service. Tin roofs are usually soldered together. Galvanized iron and other iron roofing materials are usually so constructed that one piece overlaps the other in a standing seam, with special methods of fastening. In laying metal roofs, provision must be made for the expansion and contraction of the metal.

Slate Roofs

266. **Slate roofing** is laid and used in a manner very similar to wood shingles. The slate are about three-sixtenths of an inch in thickness. Lengths vary from twelve to sixten inches and widths from six to ten inches. Tinned or galvanized nails are used in laying slate roofs, as an ordinary nail would rust off before the roof would need repairing.

Tile Roofs

267. **Tiles** for roofing are made from select clays which are burned and chosen for color effect. See Art. 208.

Concrete Roofs

268. In some sections of the country, concrete, molded in various shapes and sizes, is used as a roof covering. It is made with reinforced metal and is provided with methods of fastening. It costs less than tile roofing materials, but is not as satisfactory, being more absorbent and more likely to be affected by weather conditions.

Bituminous Roofings

269. Roofs in which bituminous materials form an essential element are of two types: a built-up type, in which the various materials are assembled on the building; and the "prepared," or "ready" roofing, which comes ready to be fastened to the roof deck. From the standpoint of fire risk, the built-up types deserve more consideration than

is usually given them. A built-up roof composed of the best materials should last from fifteen to thirty years. The prepared roofing materials are, for the most part, used on temporary buildings.

Gravel Roofs

270. A gravel roof is the most common form of built-up bituminous roof covering. Gravel roofs are usually laid upon large, flat-roofed buildings. First, it is necessary to have a good, solid roof floor, upon which roofing is laid with a lap two-thirds the width of the felt. All the layers, except the first, are well coated with pitch. The first layer is not cemented to the base, but is so laid that the shrinkage of the base will not affect it. After the last layer is on and securely nailed down, the entire surface is covered with a heavy coat of pitch, moderately hot, and over this, clean, well screened gravel is spread.

"Ready," or "Prepared Roofing"

271. These roofings, with the exception of the shingle type and a few others, come in rolls sufficient to cover one to two squares each. They vary from the lightest felt, inexpensively made, to a several-ply sheet, so heavy that it cannot be rolled. They are made with either coal-tar pitch or asphalt. One of the weaknesses of this type of roofing is, that despite all care exercised, it will stretch or wrinkle owing to varying weather conditions, which results in wrinkling the felt. After a time these wrinkles are likely to break, especially if walked upon. Moreover, the material, being very light, is easily torn from the roof by wind, in case a break develops anywhere in the roof covering.

Some of the prepared roofings heavily coated with coarse sand or crushed slate are cut up into shingles of various sizes. For the most part these singles are used on smaller buildings and dwelling houses. They present a pleasing appearance.

Miscellaneous Materials

Graphite

272. Graphite is a form of carbon. It is of a black or dark grey color and has many uses, the most common being in the manufacture of lead pencils. Graphite occurs in scales or flakes and has a soapy,

greasy feel. It is a fossil mineral material the same as coal. It is mined and prepared for the market by grinding and washing.

Graphite is used as a lubricant in place of oil. It forms the base of metallic stove polish, is used as an iron paint and, mixed with clay, in making crucibles. It is commonly sold in the form of flakes, grease, and sticks.

Putty

273. **Putty** is made by mixing finely ground limestone, called whiting, and linseed oil. It is worked to a doughy mixture and is used by painters in filling cracks, holes in woodwork, etc. Its common use is in setting glass. The putty, after exposure to the air, hardens and holds the glass firmly in place. Often paint or stain is mixed with putty to give it color. A good formula for putty is as follows: Mix equal parts of finely ground whiting and white lead with enough linseed oil to make a thick paste, then add whiting until the desired body is obtained.

Tar

274. **Wood tar** is a product from the distillation of several kinds of wood, as pine, fir and larch. **Coal tar** is a by-product of the manufacture of illuminating gas from coal. When the word tar is used alone, wood tar is meant. Tar is a sticky liquid of a dark color, it has a strong, pungent odor and was at one time much used as a lubricant. Other and better lubricants have almost entirely taken its place. It is used for preserving timber exposed to weather, for calking seams in boats, and as a coating in various forms of roofing materials. Medicinally, it is valued as an antiseptic, and is used for treating skin diseases. Also it is used in cough medicines and in soaps.

There are two methods of producing tar: (1) stacking and slow firing the wood in a built-up cave of earth, and (2) distilling it in retorts or ovens. The latter is the more economical and is the method used almost entirely at the present time. Also, it makes possible the separation of other valuable by-products.

Coal tar is obtained at the rate of about ten gallons to a ton of coal. It is used in the preservation of timber and in the manufacture of tar paper and roofing materials. The products of coal tar are many, among which may be mentioned benzine, oil, and dyes which have largely displaced vegetable dyes in coloring.

Solder

275. In cementing metals together, an alloy in the form of **solder** may be used. Solder in a molten state is applied to the surfaces to be united and for that reason must be of such a composition that it melts at a lower temperature than the metal upon which it is placed.

Solders vary greatly in composition according to the use for which they are made. A soft solder for general use on tin, copper or brass surfaces is made of one part tin and two parts lead, while a harder solder consists of two parts tin and one part lead.

Spelter solder is two parts copper and one part zinc. Special soldering alloys are made for use on gold, platinum, aluminum, silver, etc. The solder should, as nearly as possible, resemble the color of the metal on which it is used.

In soldering, the metals to be united must be free from dirt and rust. To keep them clean during the operation, a flux is used. The flux is made of borax, resin, zinc chloride and other materials.

Babbit Metal

276. Babbit metal is a soft, white alloy much employed for machine boxings. It was invented by Isaac Babbit, of Boston, in 1841. Mr. Babbit used in his alloy twenty-four parts tin for smoothness, four parts copper for strength and eight parts antimony for solidity. Manufacturers of the metal use different formulas, according to the nature of the use for which the alloy is intended.

If the alloy is left in a fluid state any length of time without stirring, the metals of which it is composed separate into layers, the lighter metals coming to the top and the heavier ones sinking to the bottom. Bearings poured in this condition will have soft spots and hard spots.

Glue

277. Glue is the best known of the many adhesive materials. Based upon the material from which it is made, glue is classified as animal and fish glue. Animal glues are made from hides, hoofs, horns, bones and sinews of animals.

There are no tests that can be employed satisfactorily to determine definitely the quality of glue at the time of purchase. Dry glue should have little color, but transparency and a light color do not always indicate good quality. The strongest glues may be dark in color. Good glue will swell in water, but will not dissolve until the water

nearly reaches the boiling point. It will also absorb more water than poor glue and therefore is more economical. A safe way to determine the adhesive properties of glue is to give it a series of actual tests.

278. **Dry glue** may be purchased in the form of sticks, flakes or ground glue. All these may be made from the same grade of glue stock, but, in general, there is a feeling that ground glue is less valuable, being more open to adulteration. The above forms of glue, when ready for use, constitute what is known as "hot glue;" that is, they are melted and applied hot. To use hot glue, the glue is reduced to small pieces and somewhat more than covered with cold water and allowed to soak thoroughly(usually over night). The excess of water is then poured off and the glue is melted. By frequent melting, or long continued heating, the glue loses its strength; therefore, it is best to make up at one time only enough for the work at hand.

279. **Liquid Glue.**—Certain acids and salts added to melted glue preserve it in a liquid form when cold. Liquid glue may be used cold and for this reason is termed "cold glue." Cold glue is more convenient than hot glue and has supplanted it for many uses, such as furniture repair work, gluing up intricate work, and places where it is impractical to use hot glue. Cold glue does not hold so well nor as permanently as the best grades of hot glue, but cold glue has been much improved in recent years and, for general purposes, is perhaps as good as ordinary stick glue.

A typical formula for liquid glue is as follows: Soak 30 grams (one ounce) of dry glue in 90 cubic centimeters (3 fluid ounces) of acetic acid of ten per cent strength. Warm slowly in a glue pot to dissolve the glue. When cool, it remains liquid.

280. **Fish glue** is made from the air bladders, scales, heads and vicera of fish. Much of the liquid glue sold is fish glue, though liquid glue may be made from animal glue.

SECTION THREE

TOOLS

by

L. DAY PERRY,

Supervisor of Industrial Work, Public Schools,
Joliet, Illinois.

TOOLS

1. The lowest tribes of men make, and have made, tools of remarkable ingenuity. The first traces of man indicate that he knew the use of fire and manufactured tools and weapons suited to his need. These distinctions mark him off in a general way from all other living creatures.

It is a difficult and rather inaccurate process to trace the development of tools from pre-historic times, owing to the fact that remains are meager and evolution hard to establish. However, the history and development of tools have gone hand in hand with the history and progress of man. Though widely separated over the earth, and without means of communication, it is interesting to note that different groups of men developed tools in a similar manner.

2. **Earliest Stone Implements.**—Implements made by the driftmen have been unearthed in different parts of the world, and collections of their work show a striking resemblance. Except for the character of the material employed, all these tools might be attributed to one tribe, so near alike are the specimens. Driftmen preceded the cavemen. Implements made by the cavemen have been found in the caves of France and Belgium and in beds of drift gravel deposited by ancient rivers. Among the early specimens of man's ingenuity are tools of bone; but probably the first tools showing any special degree of workmanship were fashioned from stone. It is conceivable that pre-historic men fashioned wood into tools, but naturally any such tools have perished, just as modern wood appliances will have rotted and disappeared centuries hence. Perhaps the oldest tool employed by man was a pounding tool, consisting of a smooth, round stone. Such an instrument could be used for various purposes. It became alike a weapon for defense and a means of providing food. With the advance of time, the one tool of such useful properties was gradually developed into several tools, each better adapted to its function. Chipped to a point, it became a spear; chipped to an edge, it became an axe; while blunted, it became a wedge. Gradually man worked out processes in manufacturing or fashioning these various tools of which the pounding tool was the parent. Of these processes, the chief ones were chipping, polishing and drilling. Therefore, man's progress is indicated by the processes used in evolving tools. Some tribes learned very slowly beyond the chipping stage.

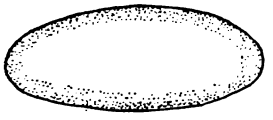


Fig. 1—Hammer stone.

Fig. 2—Flint Scraper.

The chipping of stone or flint was accomplished by striking one stone against another. Skill was necessary to bring the stone to the desired edge or point. It is evident that the manufacture of these tools was carried on with diligence, and surely primitive man must have been patient. This period is called the **Old Stone Age**, or the period of crude, rough instruments.

Fig. 3—Flint Awl.

Primitive man's discoveries in stone working probably induced rapid strides in making tools of wood, bone, shell and horn. Also, the necessity of fastening the handle to stone hammers and axes caused him to discover resins and similar agencies, and to use cords made of animal products and twisted canes, reeds and grasses.

3. The Ages of Mankind.—There is no definite division between the various periods or ages in man's development. The products of the industry of primitive man in America resemble the products of the European primitive man in the stone age, this resemblance being striking in the case of chisels, axes, etc. The Indians of America, however, used granite, jade, quartz and obsidian, instead of the flint used by Europeans. Neither axes nor stone hammers pierced with a hole for the handle have been found generally in America. The fact that the tools used by the early Americans and Europeans are very similar, though widely separated in time, suggests that the age of stone is not the inheritance of any one people. In reality, it represents a stage in human progress which at some period has occurred in almost every part of the world. At this time, in some parts of the world, the age of stone has not passed. In certain remote districts of Ireland, stone hammers are still in use; the Indians of certain sections of Mexico employ stone lancets, and a very few years back, before the advent of the white men, the Indian of Alaska was in his full Stone Age.

Roughly classified, and in simple terms, man has developed through five periods of time, no one of which represents a given span of years or a definite time in history. They are: (1) the Early Stone Age; (2) the Later Stone Age; (3) the Age of Copper; (4) the Bronze Age; (5) the Age of Iron.

In certain mounds in America, tools of stone and flint and pure copper, both rough and polished, have been found. This indicates that at one time stone and copper were used concurrently. Some peoples probably passed completely over one or more of these ages, in that they did not work in the materials that the age represents.

This may be said of the negroes of Africa, who passed from the stone age directly into the age of iron. They fashioned no tools of copper or of bronze, but, judged from the primitive standpoint, they did bring their tools and weapons of iron to a high state of perfection.

The art of grinding, polishing and boring slowly came into use. These processes were first carried on by means of sand and water. Boring was done by twirling a hollow reed or pointed stone against the stone to be bored. The discovery of these processes made possible better tools, in that the hammer, axe, maul, chisel, etc., could be more securely handled than by tying, as originally practiced. Better workmanship was practiced and more convenient tools came into use as the stone age advanced, yet rapid progress was not evidenced until the discovery of iron. This may be accounted for by the fact that iron is practically the only metal that is pre-eminently suited for tool making.

4. The Use of Copper.—The ages of copper and bronze overlap to such a degree that it is not certain which should be given precedence. It may be presumed that since copper is easily obtained in a pure state, and can be readily fashioned into various shapes, that it was used for tools in advance of bronze. Because of the pliability of copper, it was used early by man. He found it relatively easy to manipulate into various forms, and its brilliant color appealed to him. Probably before he fashioned it into tools, or even thought of it in such a connection, he fashioned the metal into articles of adornment. More copper objects of ornament than industrial tools have been unearthed from mounds in America.

The American Indian used fire in working copper. He melted the ore in crude clay furnaces, after which the pure copper was removed from the bottom of the oven, where it occurred in irregular masses. He worked these pieces by hammering them with stone tools, and reheating as necessary, until the finished ornament or tool was satisfactory to his primitive eye. Mounds of the Lake Superior region have given up copper arrow heads, hatchets, hammers and knives of remarkable design.

In the Lake Superior region to-day are the great copper mines of America, and at the same place centuries ago the Indian carried on his primitive mining operations. In one of the old mines were found wooden shovels, levers, bowls and troughs, presumably used by the Indians. Quantities of stone hammers, well handled, were found along with rude copper wedges. Mining was undoubtedly carried on

after the following fashion: The soil was loosened and removed with wooden shovels and sticks; the exposed rock was heated by building a fire upon it; with the aid of bowls, water was then thrown on the hot stone to cause it to crack; then, the pieces of loosened ore were removed with the stone axes and mauls.

Thus, we find in one section of the country primitive man working, in his crude way, the copper with his rough stone and wooden tools, and shaping the metal to suit his peculiar needs. It is a wide step to the extensive mining operations of to-day, carried on in the identical locality. The discovery of metal gave the greatest impetus to the industrial arts, and made possible the remarkable tools and machines of the present era. To primitive man must be given the credit for the discovery of these metals, and the resulting rude tools, which were forerunners of the tools of today.

5. **Bronze and Iron.**—The use of bronze is generally conceded to have followed that of copper. In many parts of the world no such age as the Age of Bronze existed. Bronze, a mixture of nine parts copper and one of tin, was undoubtedly brought from the East. Probably the making of bronze was discovered in districts where both tin and copper were found in a natural state, and was a purely accidental occurrence. Bronze was worked by melting the two elements and casting the compound in molds of sandstone. Tools in this epoch were all cast, generally speaking, and three methods were used in accomplishing this work.

1. The metal was cast in molds of stone or metal.
2. A model of the tool was made in wood, fine sand was then poured over it to obtain a corresponding hollow. The metal was then cast.
3. Casting with wax or wood.

Nowhere was the use of bronze more fully developed than in Denmark. There early man made tools, chisels, knives, and implements of all sorts for hunting purposes. Naturally, the shape of tools in bronze followed very closely the lines of those made in stone. The creative instinct of pre-historic men was not very highly developed; in fact, the design of his tools may be said to be more nearly accidental than the result of thought or study.

Unlike copper, iron never occurs "free" in nature, for it combines readily with other elements. Further, in contrast to copper, it needs considerable heat to reduce it from the ore. Probably these are the reasons iron ore had not been worked hundreds of years earlier.

Evidence shows that ornaments of iron were used as far back as 3500 B. C. The Chinese made use of iron long before the Christian Era, and the Assyrians are said to be the first people to use it extensively. The art of extracting iron from ore spread slowly, each worker probably learning the operation from his neighbor, and each improving in some particular way over the previous effort. The early furnaces burned wood and were on tops of hills where brisk winds produced hot fires and smelted the ore. Later, holes were dug in clay banks, and charcoal used for fuel. A hand bellows of skin with a hollow wooden nozzle furnished the blast and produced a hotter fire than natural draft.

The forerunner of our modern blast furnace was the Catalan forge. The output of this furnace could not have been of the best, judged from the modern viewpoint, for the ancients had little or no knowledge of the qualities of their tools and little uniformity of hardness of the metal resulted. Yet the tools produced from these furnaces were so superior to those of copper and bronze, that the actual advance in tool making was little short of marvelous.

Discoveries and inventions of recent date revolutionized tool making and industry. One Bessemer converter will probably turn out in a day more than did all the ancient, crude furnaces combined. Contrasted with the towering furnaces of to-day, with blast heaters, and with engines which deliver thousands of cubic feet of blast, the primitive furnace fades into insignificance. Yet, it is the inceptive invention which developed into the modern steel plants, which in turn make possible the giant machines used in saw-milling, stone cutting, leather working and printing; it has made possible the steel tools of the carpenter, the mason, the draughtsman, the electrician, and the delicate instruments of the surgeon and the dentist.

6. The First Stone Tools.—It cannot be stated with any degree of certainty the type of tool man manufactured originally for his use. It is believed that a tool of the type of a hammer was first conceived. For defense and for industry, a smooth, round stone (Fig. 1) was easily grasped in the hand, and materially increased the power of the blow. Later, probably more through accident than design, man discovered that for scraping the hides of animals, a stone with a sharp edge (Fig. 2) became an effective tool. This represented a distinct step forward in tool development, for he depended upon the skins of animals for part of his clothing and shelter, and his labors were materially decreased by having an instrument adapted to his work. Later, he found the need for a tool which would bore into other stones,

so he fashioned stones to a point after the manner of an awl. See Fig. 3.

It is relatively well established that the first "kit" of tools included a hammer, a scraper, an awl and a saw. From each of these, differentiations came about gradually, but steadily, and they are the parents of our perfected modern hand tools. It must not be understood that man first had the several rude tools mentioned, but rather, each developed gradually as need arose, and as inspiration or accident prompted their manufacture. Figs. 1, 2 and 3 suggest types of tools first conceived by primitive man. These were crude, unfinished instruments, yet they represent the fruits of painstaking labor expended in an effort to shape natural stones to suit simple wants. These were as truly tools as our steel hand tools of to-day, and perhaps represent the same rapidity of progress when judged from the pre-historic standpoint.

7. Development of the Hammer.—Tracing the development of certain tools from ancient times to those of the present day, establishes a progression typical of many tools. It is impossible, in this short space, to trace the history of groups of tools and machines, and, as suggested, all do not have their prototypes in pre-historic times. The saw, hammer and chisel have been used by all peoples of the earth, just as the forge and the furnace of varying degrees of development have been the peculiar heritage of all peoples dating from the discovery of fire. They were tools and appliances for which people of all times have had need. Our first type study will be that of the hammer.

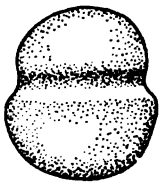


Fig. 4.

A flat, round stone was the first implement used for pounding and beating. Held in the hand, it increased many fold the power of the blow that man was able to impart with his naked fist, and was still further increased with stones of larger size, limited only by the ability to grasp and swing them effectively. Very early, man discovered that the power of the blow could be increased, if the stones were fastened in some maner to a stick of convenient length. The hammer progressed through a series of steps which may be indicated in the following manner:

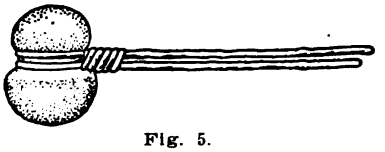


Fig. 5.

1. The round stone, called the hammer stone.
2. Grooved, to attach handle with withe or rattan.
3. Bored, to attach handle directly.
4. Using these to fashion hammers of copper.
5. Casting bronze hammers in molds of stone.
6. Forging hammers of iron.

The first "handling" or "hafting" of the hammer stone necessitated grooving it so the handle might be held securely. Fig. 4 shows a grooved stone. This was accomplished by rubbing a second stone against it either with or without the aid of sand and water. Fig. 5 shows the method of fastening two green branches or twigs to a grooved hammer stone. These sticks were bent around the stone and fastened securely with strips of hide or withe. As the withe dried, it shrunk and thus made a snug fastening. Frequently, split rattan and grasses were used for this purpose. Pre-historic man used stout sticks, bone and horn for handling his hammers. Many unearthed specimens show how ingeniously man hafted hammers, axes, mauls and spears.

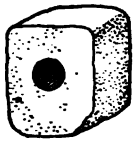


Fig. 6—Hammer stone with hole for handle.

With the discovery of boring, a hole was made in the hammer stone (Fig. 6) and a stout stick was wedged in the hole much after the fashion of the modern hammer. Fig. 7 shows a stick or branch in-

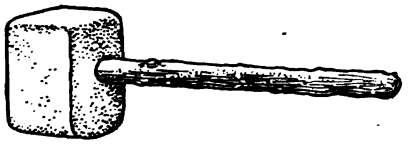


Fig. 7.

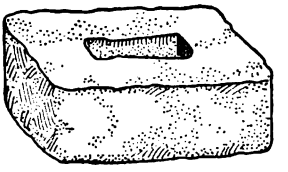


Fig. 8.

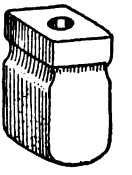


Fig. 9.

serted. In addition, the two parts were frequently bound with leather thongs. With the discovery of copper and bronze, the hammer made rapid strides toward perfection. The copper worker pounded out hammers of copper with hammers of stone, and the former supplanted the latter. Later he cast hammers of bronze in molds of stone. The depressions in the stones were bored and chipped. Fig. 8 shows such a mold and Fig. 9 a hammer of cast bronze with a hole in the upper end. Fig. 10 illustrates the method of handling this type of hammer with an angled stick.

With the discovery of iron, hammers were both cast and forged. As specialization became more pronounced, hammers were made in various shapes and weights, with handles of various shapes and lengths, each to serve its special function. Fig. 11 illustrates the modern claw hammer of general use with its machine turned handle. Today, hammers range from the great trip hammer, with its hundred-ton blow, to the small delicate ones used by the watch maker, each carefully planned for its particular field. To enumerate these would serve no particular purpose here, but it is interesting to note that all are built on the principles which primitive man discovered as being most effective.

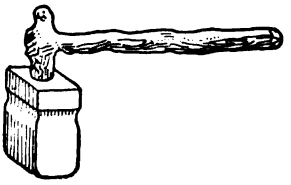


Fig 10.

Fig. 11.

8. **The Saw.**—Before history was recorded in written form, primitive man was acquainted with a crude saw. The indispensibility of such a cutting instrument is indicated by the fact that some form of serrated tool was employed by all tribes of early man throughout the world. This is also true of the hammer, the celt and the wedge. In Fig. 12 is shown the saw of flint, probably the earliest type of saw of which there is a record. Records show that a very crude, yet effective, hand saw was known to the craftsmen of ancient Greece and Egypt. The inhabitants of the South Sea Islands used a saw composed of shark's teeth, arranged in rows, and ingeniously imbedded in wood; certain Indians used notched clam shells, while the ancient Mexicans utilized slivers of volcanic rock. Fig. 13 shows a saw made of parallel rows of shark's teeth imbedded in wood.

Fig. 12—Flint saw.

Fig. 13.

It is problematical as to how early man came to fashion saws. The suggestion may have come from the rough irregular edge of a clam shell or from the peculiar snout of the saw-fish; or, perhaps the discovery was purely accidental. The savage used a saw to cut across the grain of wood. When he wished to cut lengthwise of the grain, instead of having a rip-saw, he employed a wedge which split the

wood fibers along the line of the medullary rays. The rip-saw is a relatively modern invention.

The Bronze Age developed saws which were a great improvement over those made of stone, for the efficiency of the saw of bronze was much greater than that of stone, although the task of keeping a relatively keen cutting edge was difficult. The bronze saw may be considered an indispensible tool of that period, for it was used in all industries. Fig. 14 illustrates a saw of bronze with holes made at each end for pulling. It may be noted in all of these illustrations that the saw teeth are not set forward as in the modern saw, and the saw blade is made rather thick. Thickness was necessary to keep the tool rigid under strain. Fig. 15 illustrates an early Egyptian saw of bronze set into a handle. In common with early Japanese saws, the teeth were arranged to cut on the pulling stroke. Early bronze and iron saws were generally made to cut on the pulling stroke for the reason that a pushing stroke would buckle the metal. In parts of Japan and China, crude saws operated by pulling are still in use.

Fig. 14.

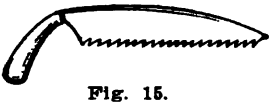


Fig. 15.

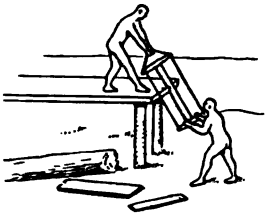


Fig. 16.

The discovery of iron made possible the manufacture of varied types of saws of great effectiveness, and from this period begins the era of the saw's most rapid development. The invention of steel was the greatest stimulant to the development of the saw, as it was to practically all other tools.

For many years there existed but one type of saw and that was the hand saw. The first two-man saw consisted of a blade with a cross piece attached at each end to serve as handles and the saw was pulled up and down through the work. In sawing with the two-man saw, the work was propped up and one man worked, standing above the wood, and the other stood underneath. The method was crude, the saw was thick and the labor tremendous. Fig. 16 illustrates such a two-man saw with the top sawyer and the pit-man.

All saws, both ancient and modern, may be divided into two general classes: reciprocating and continuous action. Reciprocating saws are the oldest type, and all hand saws previously mentioned and illustrated are naturally of that type, the fore-runners of the saws of today. Fig. 17 shows the first power saw of the reciprocating kind; Fig. 18 illustrates the first power machine employing a saw of

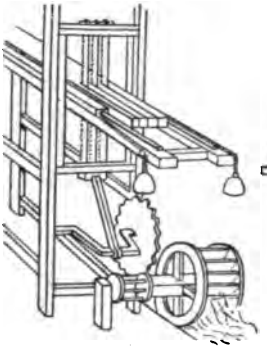


Fig. 17.

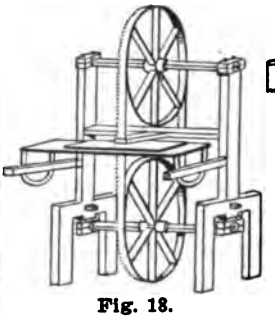


Fig. 18.

Fig. 19.

the continuous type. Such saws were impossible previous to the invention of tempered steel.

To-day in the great sawmills of the Northwest are modern circular and band saws of the finest tempered steel. Run at a tremendous rate of speed, they cut with ease and facility the logs automatically fed to them. These mill-saws are a necessity in modern civilization, but are no more important than were the rude stone and bronze saws of early man, or the unfinished, unevenly tempered saws of our forefathers.

Fig. 19 illustrates a modern hand saw. It is made of finely tempered steel and retains a keen edge for a considerable length of time. This saw, with its many modifications of type, as the hack saw, butcher's saw, jointer's saw, turning saw, coping saw, and the like, is used by practically every industry in the world.

9. Other Tools.—Although the evolution of but few tools extends into the pre-historic past, a study of their development reveals that each was evolved to fill a certain definite function and was designed to work with the least expenditure of energy. Also, each modification admitted of greater facility for work in special lines as trades became different and more complex. From a few, crude, basic tools we now have varieties of standardized tools, common to most of the trades, and sold on the world markets. Other tools developed are so special that they are either made to order or especially made by the worker, as for example, the cutters of the block-cutter in the wallpaper printing industry.

Every industry needs those tools and machines which make for speed and maximum production. As our social and industrial requirements become more and more complex, it is imperative that tools be designed with that thought in mind. So, to meet definite needs in each trade and industry, machines and tools have been invented and come into use, each with a view to the elimination of waste both in human energy and in materials.

In most trades, workmen require a number of hand tools and accessories to work effectively. Among such trades are plumbing, steam fitting, pattern making, machine shop work, sheet metal work and general carpentry. On the other hand, there are certain trades and industries which require a minimum of hand tools, among such are brick and tile making, leather tanning, saw milling, logging and the textile industry. In the first group, the workman performs manifold operations on a single unit of work which he completes, thus requiring a rather varied set of tools. In the latter group, machines have supplanted hand tools to such a degree that each workman becomes a machine operator, or his work consists of the performance of definite processes which necessitate a minimum number of hand tools.

Judged from the modern viewpoint, the tools of primitive man are apt to be considered crude and ineffective. Yet they fulfilled the needs of the time and their inventions were progressive. Just as our inventions fulfill certain functions, so did theirs, and just as their inventions were changed and improved to meet new conditions, so will ours be altered to meet future requirements.

As civilization becomes more complex, differentiation of tasks increases, until problems of living demand the use of many different kinds of tools and implements. The savage used the same tool for all work of one class. For example, he had one tool to be used for all cutting work, whether disposing of an enemy or obtaining food. Not only were there but few tools and no specialization of industries among the uncivilized, but the energy required to manipulate the tools was so great as to make most work exceedingly slow and tiresome. Gradually through the stimuli of necessity, a number of tools were developed for each division of work. Instead of having one cutting tool, a number are now in use, each especially designed for a particular purpose. Some are hand tools, others are machines, and the list is being extended as new problems in this class of work are met. The same is true for each class of tools.

10. Classification of Tools.—Previously, we have considered individual tools from the standpoint of their development to meet special needs. We now come to a study or grouping of them on the basis of what can be done with them. Although tools may vary in shape, or size, they may be designed to perform the same operation in different materials, or to do the work in different manners in the same material. Thus a pair of snips cuts metal; an ax cuts wood, and a saw cuts wood or metal. Although the process, cutting, is the same, the tools are different. A certain tool may be used in

almost all kinds of work, but in each case the use of the tool is, in general, the same. Thus a butcher and a cabinet maker each uses a knife, and while the work is widely different, in both cases, the knife is used for cutting. On this basis of classification, all knives may be classed as cutting tools. Likewise all tools used in modern trades and industries may be classed in the groups given below. In studying tools under these general headings, the chief interest is in the general use of the tool rather than by whom and where it is used.

1. **CUTTING TOOLS**
   - As Knives
   - Saws
   - Axes
   - Chisels
   - Snips
   - Nippers

2. **PERFORATING TOOLS**
   - As Bits
   - Drills
   - Punches

3. **HOLDING TOOLS**
   - As Vises
   - Clamps
   - Pliers

4. **ABRADING AND SMOOTHING TOOLS**
   - As Scrapers
   - Files
   - Burnishers
   - Grindstones
   - Whetstones

5. **MARKING AND MEASURING TOOLS**
   - As Rules
   - Gages
   - Steel Squares
   - Dividers
   - Calipers
   - Trammels

6. **POUNDING AND CRUSHING TOOLS**
   - As Hammers
   - Mallets
   - Sledges

In connection with the above classification, study tools under Sec. 4.

11. Trade Sets of Tools.—In any industry, a trade consists of the performance of certain operations which, through long and continued practice, have become identified with that line of work. Naturally, to perform such operations, the tradesman must bring into use the particular tools, machines and equipment suited to the work. Here again practice has determined the most suitable tools, machines and equipment necessary in each line of work and such items considered as a whole form a **trade set.** In vocational work, the study of a tool is not so important in itself as the study of its use and relation to other tools in the set. A comparison of tool sets employed in the industries is desirable both from an educational and industrial viewpoint. Trades overlap. Many are inter-dependent. Therefore, a knowledge of the equipment of the workers is

desirable. The more common trade sets of tools are given in this section. Also, sets used in certain trades which are highly specialized are given.

Almost every workman has some particular or special tool which he has come to consider necessary, but which is not common to the group. Neither these tools nor those which have been considered dispensible have been included. The sets listed here are recognized sets and give the tools, machines and equipment considered necessary for effective work in the trades. They were compiled with the industrial viewpoint in mind.

12. **Farmer.**—The tools specified under this head are considered necessary ones on a properly equipped farm. The operations, which

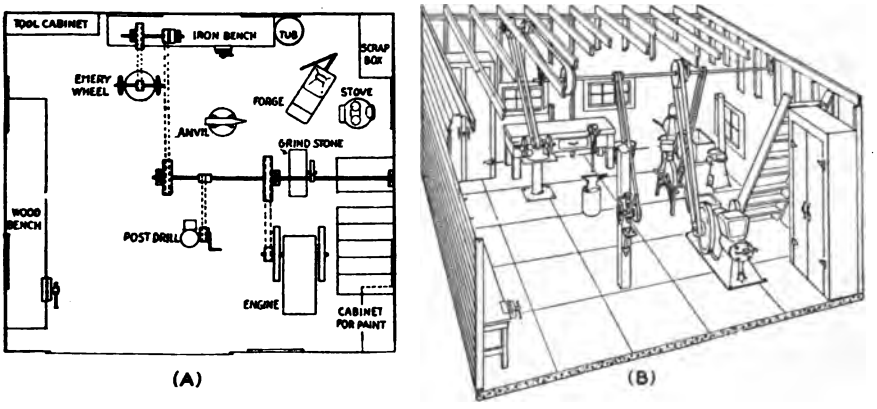


Fig. 20—Plan of practical farm workshop.

the farmer must perform in the usual run of his work are,—general wood repair work on implements and household furniture; the manufacture of coops, sheds and traps; harness repairing; grinding cultivator shovels, discs, etc.; and the manifold upbuilding operations about the farm. These operations form portions of work of various tradesmen, therefore, his workshop should be well equipped.

CARPENTRY

Brace	Rip Saw
Bits, Twist and Auger	Jack Plane
Claw Hammer	Chisels
Steel Square	Draw Knife
Try Square	Dividers
Hand Saw	Screw Driver
	Nails and Screws

Fig. 21—A farm workshop.

BLACKSMITHING

Cold Chisels
Punches
Hack-saw Frame
Hack-saw Blades
Files, Handled
Ball Pein Hammer
Center Punch
Anvil

MACHINES

Grindstone

HARNESS REPAIR

Hand Belt Punches
Belt Awl
Rawhide Laces
Copper Rivets and Burs
Lever Riveting Machine and Equipment

MISCELLANEOUS

Monkey Wrenches
S-Wrenches
Wire Cutting Pliers
Hatchet
Axe
Pointing Trowel
Shovel
Paint Brushes
Putty Knife
Glass Cutter
Pinch Bar
Tin Snips
Soldering Outfit
Buck Saw

13. Stone Cutter.—Stone cutting is done generally by machines, but the stone carver uses hand tools. These dull rapidly, requiring frequent sharpening and shaping. The tools listed are standard and common to the trade. Some of the hand tools are illustrated.

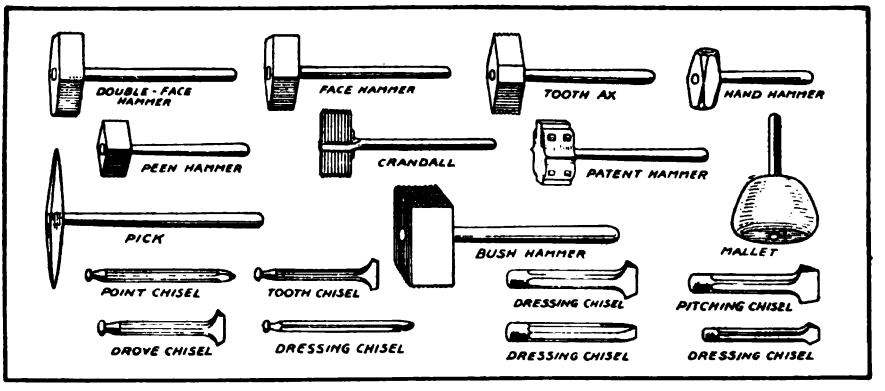


Fig. 22—Stone cutting tools.

HAND TOOLS

Bull Set
Sledge
Mallet
Points or Tooth Chisels
Pitching Tools
Drills
Plug and Feather Tools
Peen Hammer
Bush-Hammer
Bush-Chisel
Splitter
Rasp
Mash Hammer
Lettering Tools, Assorted
Templets
Sliding T-Bevels
Square

Whisk Broom
Pneumatic Tools, if run with compressed air

MACHINES

Channeler
Derrick
Hand Car
Traveling Crane
Gang Saws
Rubbing Bed
Tile Attachment
Turning Lathe
Diamond Circular Saw
Planer
Moulding Tools
Grindstone
Emery Wheel
Circle Planer, with Tools
Marble Machine
Polishing Machine, with Revolving Discs of
1. Carborundum
2. Pumice Stone
3. Hone
4. Buffer
   a. Putty Powder
   b. Oxalic Acid

Blacksmith Shop, for tool making and dressing.

14. **Architect.**—The drawing outfit used by the mechanical drawing student is made up of items which form part of the architect's equipment. The architect uses longer, as well as special T-squares, large drafting boards, etc., but his work is accomplished with instruments such as a mechanical draftsman uses.

Fig. 23—An architect's office.

HAND TOOLS

Scale
Pencils—hard and soft
Tee Square
Triangles
Irregular Curves
Erasers—pencil and ink
Art Gum
Straight Edge
Sand Paper
Drawing Instruments
Protractor
Rule—six foot
Slide Rule
Colored Pencils
Brush
Erasing Shields
Seal

EQUIPMENT

Detail Paper
Tracing Cloth
Tracing Paper
Tracing Cloth Powder
Drafting Boards
Drafting Board Covers
Small Tables
Detail Board—Large
Water Colors
Water Color Paper
Stools
Inks
Filing Cabinets
For Tracings and Prints
For Specifications
For Catalogs and Books
Books on Design, Engineering, etc.
Building Regulations

15. General Carpenter. — Carpentry is divided into a number of divisions, as the bridge carpenter, boat carpenter, car decker, carriage maker, ship carpenter, stair builder, door hanger, etc. It is unnecessary to suggest tool lists for each branch, as most of the tools listed herein are used by the tradesmen of each. The trade set listed gives the necessary tools for the general carpenter.

Fig. 24—General carpenters at work.

(Copyrighted by Underwood & Underwood, N. Y.)

Fig. 25—Ship carpenters.

THE KIT

Hand Saw
Rip Saw
Try Square
Steel Square
Level
Jack Plane
Smooth Plane
Rabbet Plane
Rule
Measuring Tape
Brace
Auger Bits
Twist Bits
Automatic Drill
Drill Points
Chalk Line
Screw Drivers
Chisels
Nail Set
Knife
Scrapers
Marking Gage
Trammel Points
Bevel Protracter
Dividers
Mallet
Claw Hammer
Brad Hammer
Sliding T-Bevel
Plumb Bob
Smooth Files
Saw Files
Bastard Files
Saw Clamp
Oil Stone

SUPPLEMENTARY TOOLS

Hatchet
Jointer Plane
Pinch Bar
Miter Box
Shingling Hatchet
Coping Saw
Router
Combination Plane
Gouges
Clamps
Draw Knife
Adze

MACHINES AND EQUIPMENT

Band Saw
Circular Saw
Grindstone
Emery Wheel
Ladders and Scaffolds
Ropes and Pulleys
Derricks

16. Stone Mason.—Very few years ago no special divisions of masonry existed. Today masonry is divided into several pursuits, as Stone Mason, Brick Mason, Fire Brick Mason, Furnace Liner, etc. In the trades, the term, mason, is now used to indicate those who lay or set stone, while bricklaying is the one applied to the workman who lays brick. Each tradesman requires but few tools to ply his trade. The stone mason's outfit follows:

HAND TOOLS

Steel Square
Pointing Trowel
Trowel
Level
Mallet
Pick
Tooth Axe
Crandall
Bush-Hammer
Points
Special Chisels
Pitching Tools
Bull Set
Sledge
Hammers
Spalling
Machine
Pein
Patent
Chalk Line
Plumb Bob

EQUIPMENT

Derrick
Block and Tackle
Wheelbarrows
Hoist
Shovels
Hoes
Hods
Scaffolds
Anchors
Mortar Mixers
Mortar Boards
Sand Screen

Fig. 26—Stonemasons at work.

17. Bricklayer.—The average bricklayer's outfit includes hand tools and some equipment as wheelbarrows, mixing and mortar boards, screens, shovels, etc., but, on large jobs, derricks and other items may be needed.

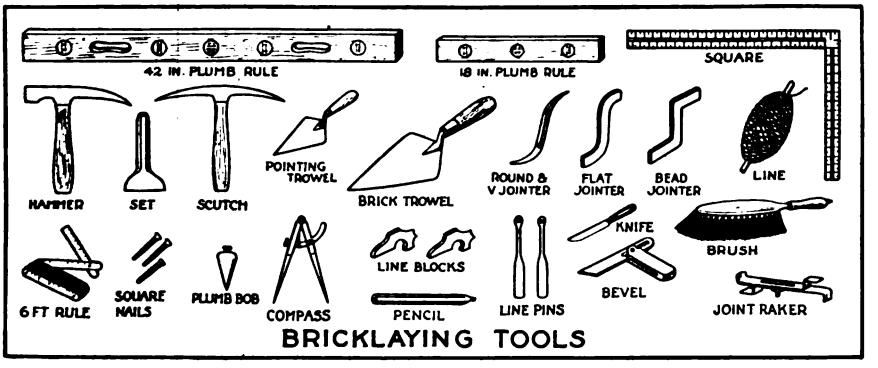


Fig. 27.

Fig. 28.

HAND TOOLS

Joint Raker	Brick Trowel
Plumb Bob	Pointing Trowel
Brush	Brick Hammer
Chalk Line	Brick Set
Scutch	18″ level or plumb rule
Compass	42″ level or plumb rule
Line Blocks	Brick tongs
Line Pins	Six foot rule
T-Bevel	Square nails
Square	Pencil
Jointers	

EQUIPMENT

Same as for stone mason.

18. **Plumber.**—The plumber does repair work as well as construction and installation of fixtures, etc. The work may be in a basement or in a wood, stone, brick or concrete structure. He works under all kinds of conditions, so his equipment is rather extensive, but consists mostly of hand tools.

TOOLS

Stock and Dies	Wood Chisels
Furnace	
Pipe Cutters	Twist Bits
Taps	Tape Line
Vises	Folding Rule
Ladle	Plumb Bob
Soldering Irons	Expansive Bit
Drills	Spirit Level
Reamers	Pot Hook
Monkey Wrenches	Bending Pliers
Pipe Wrenches	Tap Borer
Friction Wrenches	Turn Pin
Basin Wrenches	Drift Plug
Pliers	Dresser
Torch	Cold Chisel
Screwdriver	Track Mold
Rasp	Shave Hook
Files	Wiping Cloths
Mallet	Picking Chisels
Compasses	Picking Tools
Hand Saw	Brace
Hack Saw	Caulking Tools
Keyhole Saw	Bending Spring
Wood Gouges	Bossing Sticks

Fig. 29—Plumbers laying soil pipe.

Pipe Benders	Oil Can
Snips	Whet Stone
Expanding Pliers	Tool Bag
Valve Reseater	

MACHINES AND EQUIPMENT

Grinding Machines
Large Stocks and Dies

19. **Steam-Fitter.**—The work of the steam-fitter includes running air, water and steam lines, making connections, attaching fittings, etc. The necessary equipment consists of—

TOOLS

Stock and Dies	Extension Chuck
Center Punch	Gimlet
Taps	Hammers
Pipe Vises	Compasses
Reaming Tools	Files
Pipe Cutters	Hand Saw
Drills	Hack Saw
Cold Chisel	Keyhole Saw
Pipe Wrenches	Rule Tape
Pipe Tongs	Plumb Bob
Friction Wrenches	Square
Monkey Wrenches	Level
S-Wrenches	Pocket Level
Pliers	Lead Pot
Screwdriver	Small Trowel
Wood Chisels	Snips
Wood Gouges	Oil Can
Brace	Whet Stone
Auger Bits	Nipple Chuck
Expansive Bit	

Fig. 30—Steam-fitters' workroom.

MACHINES AND EQUIPMENT

Emery and Stone Grinders
Pipe Threading and Cutting Machines
Oxy-Acetylene Outfit
Furnace

20. Paperhanger.—The equipment required by the paperhanger is not elaborate and most of the tools are very simple, requiring little special preliminary knowledge or training for their use. There can be little variation in such trade sets, but with these tools much skill and dexterity may be developed by practice.

Fig. 31.

HAND TOOLS

Shears	Putty Knife
Trimming Knife	Folding Rule
Paste Brush	Tape Line
Smoothing Brushes	Rotary Trimmer
Straight Edge	Seam Rollers

EQUIPMENT

Paste Boards	Ladders
Paste Table	Pail
Extension Planks	

21. Plasterer.—For many years there has been but little change in the plastering trade. The tools have been improved in design and better materials are used in their construction than formerly. Not many new tools have been added. The mixing machine for use on large jobs is the most important addition.

HAND TOOLS

Plastering Trowels
Floats
Darby
Hawk or Hand Board
Feather Edge
Calcimine Brush
Long Rod
Pointer Trowel
Molds of Wood, Zinc and Iron
Paddle
Trammels
Jointing Tools, all shapes and sizes
Mitering Tools, all shapes and sizes
Square
Spirit Level
Plumb Bob
Comb or Scratching Tool
Hammer

Fig. 32.

GENERAL EQUIPMENT

Mortar or Mixing Box	Pails
Mortar Boards	Hods
Ladders	Wheel Barrows
Ropes and Pulleys	Hoes
Scaffolds	Mixing Machine

22. Electrician (Inside Wireman.)—The electrical profession is an extended one and very highly specialized. The tools listed are those used by the electrician who works on the interior of buildings. Other electrical tradesmen not included are Armature Winder, Auto Electrician, Crane Electrician, Storage Battery Man, Switch Board Installer, Ship Electrician, Search Light Electrician, etc.

Fig. 33.

HAND TOOLS

Chisels	Keyhole Saw
Pocket Knife	Hand Saw
Hammer	Star Drills
Srewdriver	Blow Torch
Flat Nose Pliers	Hack Saw
Cutting Pliers	Cold Chisel
Brace and Auger Bits	Tape Line
Twist Bits	Pipe Cutter
Extension Chuck	Scratch Awl
Stock and Dies	Folding Rule
Coe's Wrench	Hand Drill
Stillson Wrench	Rule
Soldering Coppers	Files

EQUIPMENT

Bench	Fishing Rope
Vises	Tapes
Fire Pot	Solder
Bending Appliances	Flux

23. Painter and Decorator.—In smaller communities there is little differentiation in this trade. In the larger cities the trade becomes minutely specialized, and divisions include Glazier, House Painter, Interior Decorator, Auto Painter, Letterer, Ship Painter, French Polisher, Sign Painter, Finisher, etc. The list below is for the general workman.

Fig. 34—The mixing room on the job.

TOOLS AND EQUIPMENT

Duster	Rubbing Brick
Wire Brush	Steel Wool
Scrapers	Excelsior
Blow Torch	Burlap
Putty Knife	Sponge
Straight Edge	Scrapers
Chalk Line	Felt
Graining Tools	Putty
Mixing Pails	Canvas Squares
Emery Cloth	Ladders
Sandpaper	Pulleys
Scaffolding	Curled Hair or Moss
Hooks and Ropes	Brushes of various kinds

FINISHING AGENTS

Plaster of Paris	Varnishes
Pumice Stone	Paint Removers
Rotten Stone	Fillers
Stains	Sizes
Paints	Wax

Fig. 35—Inside finisher.

24. Concrete Worker.—The general worker in concrete would have use for the equipment listed below. If one worked only on side walks, or foundations, or silo construction, etc., he would use only those items which were best suited to his work.

Fig. 36—Sidewalk construction.

HAND TOOLS

Steel Trowel	Straight Edge
Wood Trowel	Shovels
Tamper	Dot and Line Roller
Base Gage	Block Cutter
Edger	Level
Groover	Hand Saw
Wire Brush	Float
Cornering Tools	Axe

Fig. 37—Concrete building work.

Cutting Pliers
Hack Saw
Square
Hammer
Maul

EQUIPMENT

Mixing Boards
Wheelbarrow
Screen
Measuring Box
Hose
Clamps
Steel Forms
Angle Irons
Mixing Machines
Buckets
Water Barrel

25. Logging.—Logging does not require many hand tools but a modern outfit includes machines and equipment which greatly facilitate the work.

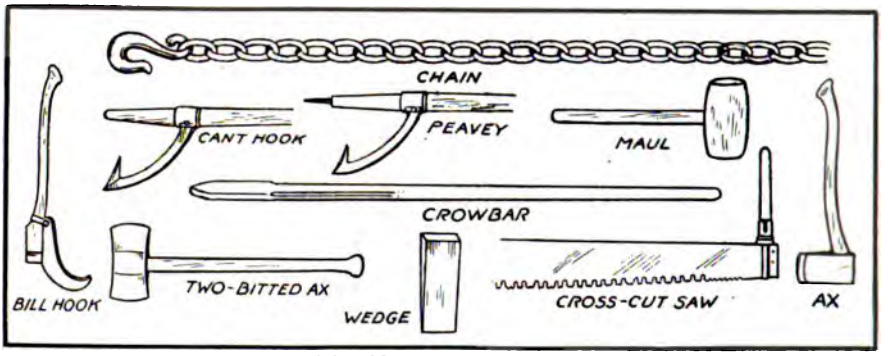


Fig. 38—Logging tools.

HAND TOOLS

Log Chains
Cable
Cant Hook
Axe
Two Bitted Axe
Crowbar
Maul
Wedge
Cross-cut Saw
Peavey
Marking Hammer
Lumberman's Rule

MACHINES AND MAIN EQUIPMENT

Trucks
Donkey Engine
Skidway
Steam Skidder
Boom Derrick
The Raft
The Flume
Traction Engine
Locomotive and Cars

26. Saw Milling.—Large mills must have adequate equipment to provide the quantity of lumber required in the trades. Machines make up most of the outfit. However, special hand tools are necessary for repair work and to keep machinery in working condition.

MACHINES

Cut-off Saw
Gang Saw
Band Saw
Circular Saw
Jack Ladder
Log Flipper
Log Stop
Nigger
Cant Flipper
Log Carriage
Edger
Trimmer
Slab Slasher
Edging Grinder
Shingle Machine
Lath Binder
Circular Re-saws
Timber Sizer
Lath Mill

(By U. S. Forest Service.) Fig. 39—View in large sawmill.

27. Planing Mill Work.—This includes not only operations in ripping, cross-cutting, surfacing, etc., but also the construction of frames, doors and similar structures through use of hand and power tools. For these varied lines of work, the planing mill must be well equipped. For general work, the following list is adequate:

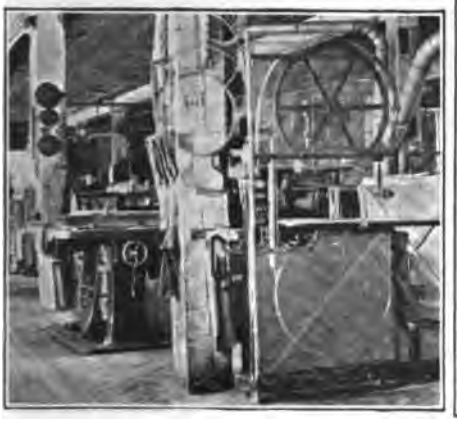


Fig. 40—Planing mill.

Fig. 41—Planing mill in connection with large saw mill.

MACHINES

Turning Lathe and Tools
Wood Trimmer
Dovetailing Machine
Tenoning Machine
Universal Saw
Drum Sander
Disc Sander
Belt Sander
Band Saw
Jointer
Surfacer
Cut-off Saw
Shaper
Moulding Machine
Mortising Machine
Glue Jointer
Grind Stone
Emery Wheel
Scroll Saw
Vertical and Horizontal Borer

HAND TOOLS AND EQUIPMENT

Same as listed under Cabinetmaker.

28. Furniture and Cabinet maker.—The cabinetmaker requires a rather varied set of tools, providing he, himself, manufactures structures in their entirety. In factories, a single workman labors on but a small unit of work, such as drawer fitting, lock and hinge setting, gluing, etc., aside from machine operation. Therefore, the tools he employs are restricted in number. The suggested list indicates the tools and machines necessary in a general cabinetmaking shop.

Fig. 42.

Fig. 43—View in large furniture factory.

TOOLS AND EQUIPMENT

Cabinet Maker's Vise
Cabinet Maker's Bench
Nail Sets
Countersink
Forestner Bits
Wood Twist Bits
Auger Bits
Automatic Drill and Points
Scratch Awl
Sliding T-Bevel
Back Saw
Coping Saw
Dovetail Saw
Rip Saw
Cross-cut Saw
Jointer Plane
Jack Plane
Smooth Plane
Circular Plane
Rabbet Plane
Cabinet Scrapers
Burnisher
Try Square
Claw Hammer
Brad Hammer
Ratchet Brace
Screwdriver Bit
Screwdrivers
Chisels
Gouges
Combination Plane
Marking Gage
Mortise Gage
Dividers
Mallet
Bar Clamps
Hand Screws
Carriage Clamps
Pliers
Draw Knife
Spokeshave
Knife
Carving Set
Doweling Jig
Dowel Pointer
Smooth Files
Cabinet Files
Saw Files
Iron Miter Box
Glue
Slip Stone
Oil Stone

MACHINES

Same as used in Planing Mill Work.

29. Patternmaker.—Patternmaking is a well defined division of work in wood and metal and is allied to the metal working trades. The patternmaker is truly a specialist. Since his work requires a combination of speed and skill, he uses a rather extensive kit. Few tools are provided in the shop. Many "special" tools are developed to suit the preference of the workmen.

Fig. 44—A pattern shop.

Fig. 45—Turning room in pattern shop.

THE KIT

Back Saw
Fore Plane
Core Box Plane
Rabbet Plane, ½" Cutter
Block Plane
Chisels, L. P. 1¼", ¾", ½", ¼"
Chisel, Bent Shank, 1"
Gouges ¼", ½", ¾", 1½" Circle
Gouge 3" Bent Shank
Carving Tools (Spoon Gouges)
Router, 3 Cutters
Bench Knife
Auger Bits, ⅜", ½", ¾"
Expansive Bit, ⅞" to 3"
Hand Drill
Drill Points, 3/32" to ¼"
Ratchet Brace, 4" Sweep
Automatic Screw Driver
Screw Driver Bit, ½"
Pinch Dogs, ¾" to 2"
Roller Gage
Combination Square 12"
Combination Pocket Square
Flat Steel Triangle, 30-60, 6"
Wing Dividers, 8"
Spring Dividers, 3"
Trammel Points
Brad Hammer
Nippers, 6"
Sliding T-Bevel
Calipers (Inside) 3"
Calipers (Outside) 4"
Spoke Shaves
Nail Sets
Oil Can
Countersink Gage
Countersink Bit, ½"
Shrink Rule (Brass, Iron, Steel)
Folding Rule, 2'
Whet Stone (Soft Arkansas)
Slip Stone (Arkansas) 4"
Whisk Broom

SHOP EQUIPMENT

Bits (Forstner), ¼", ⅜", ½", 1"
Draw Knife
Jointer
Disc Sander
Swing Cut-off Saw
Circular Saw (Universal)
Wood Trimmer

Single Surfacer
Turning Lathe, with Tools
Vertical Borer
Bits for Same, ⅛", $\frac{3}{16}$", ¼", $\frac{5}{16}$", ⅜"
Wood Miller, with Cutters
Steel Square
Glue Heater
Benches and Vises
Clamps
Jig Saw

30. Molder and Core Maker.—In certain shops, the trade is divided into two distinctive units, but here they are treated as one division of general foundry practice. The cupalo tender, furnace man, and melter are included. The specialist in this work generally prefers to carry certain tools to which he has become accustomed. These are listed under the heading of Kit.

Fig. 46—Molder at work.

Fig. 47.

THE KIT

Small Pein Hammer
Rapping Tools
Trowels
Draw Spike
Gate Cutter
Vent Pin
Slicks
Lifter

GENERAL TOOLS

Special Clamps
Moulding Sands
Mould Boards
Riddles
Rammer
Draw Plates
Strikes
Hand Bellows
Dogs
Spray Can
Flange and Bead Tools
Shovels
Flasks
Gaggers
Binders
Soldiers
Chaplets
Ladles
Ladle Tongs
Core Plates
Core Irons

Fig. 48—A brass foundry.

MACHINES

Melting Furnace
Cupalo
Core Oven
Core Carriage

31. General Machine Shop Work.—The term, Machinist, may refer to any one of hundreds of workers in metal or with machines and each may be doing different work. The work may be very simple or highly specialized and exacting. Therefore, the equipment of the Machinist varies, depending on the work he does. The list below covers general machine shop equipment.

Fig. 49.

Fig. 50—General machine shop.

HAND TOOLS, PERSONAL

Steel Scales
Combination Square
Protractor
Hammer
Center Punch
Scratch Awl
Outside and Inside Micrometer Dividers
Center Gauge
Hermaphrodite Calipers
Surface Gage
Vernier Calipers
Depth Gage
Thickness Gage
Thread Gage
Jeweler's Eye Glass
Oil Stone
Keyseat Rule
Bearing Scrapers
Screw Driver
Small Chisels
Knurling Tools

GENERAL TOOLS

Wrenches
Drifts
Drills
Drill Chucks
Reamers
Boring Bars
Clamps
Hand Vises
Angle Plates
Parallel Strips
V-Blocks
Taps
Drill Gages
Wire Gages
Center Indicaters
Dial Test Indicaters
Thread Micrometers
Snap Gages
Ring and Plug Gages
Square
Straight Edge
Breast Drill
Air or Electric Drill Motor
Trammels
Hack Saws
Files
Scrapers
Soldering Coppers
Blow Torch
Babbett Ladle
Hand Dies
Bench Surface Plate

Gear Cutters
Angular Cutters
Key-way Cutters
Fluting Cutters
Hobs
End Mills
Dogs
Arbors
Counter Sinks
Boring Tools
Tool Holders
Center Drills
Steel Figures and Letters
Speed Indicater
Level
Jacks
Belt Punch
Counter Bores
Drill Sleeves and Sockets
Pliers
Snips
Wrenches
Key Drifts
Center Grinder
Tape Line

MACHINES AND EQUIPMENT

Engine Lathes
Bench Lathe
Planer
Shapers
Milling Machines
Radial Drill Press
Speed Drill
Emery Wheel
Universal Grinder
Surface Grinder
Power Saw
Boring Mill
Bench Vise
Slotter
Drill Grinder
Key Seater
Benches

32. Forging.—Forging is divided into a number of special branches, each complete in itself. Among the workmen we find Drop Forger, Heat Treater, Horseshoer, Locomotive Blacksmith, Tool Dresser, Wheelwright, Ship Blacksmith and General Blacksmith or Forger. The printed list indicates the tools required by the latter.

HAND TOOLS

Anvil
Poker
Shovel
Calipers
Flatter
Set Hammer
Fluting Tools
Swage Tools
Tongs
Hardie
Hot Chisel, Handled
Punches, Handled
Heading Tools
Hack Saw
Files
Cold Chisel, Handled
Hand Hammer
Cold Chisels
Prick Punch
Hot Punch
Square
Dividers
Scriber
Vises
Emery Cloth

Fig. 51—The general blacksmith.

MACHINES AND EQUIPMENT

Swage Block
Tapered Mandrel
Surface Plate
Drill Press
Emery Wheel
Power Shears
Power Hammer
Forge

33. Sheet Metal Worker.—To do general sheet metal work requires an extensive equipment. Many machines make up such an outfit, as well as other special tools, but in some shops only certain kinds of work are carried on—as ware manufacturing or construction of piping, etc. Therefore, they use items best suited to work at hand. The equipment listed below is for general work.

TOOLS AND EQUIPMENT

- Shears
  - Squaring
  - Ring and Circular
- Stakes
  - Mandrel
  - Beakhorn
  - Blow Horn
  - Double Seaming
  - Hatchet
  - Creasing
  - Roundhead
  - Needlecase
  - Bevel Edge Square
- Straight Snips
- Groover
- Brake and Folder
- Gutter Beader
- Bench Plates
- Mallets
- Fire Pot
- Hand Punch
- Machines
  - Folding
  - Forming
  - Turning
  - Wiring
  - Burring
  - Elbow Edging
  - Setting Down
  - Brading
  - Crimping
  - Seaming
- Curved Snips
- Bench Shears
- Hammers
  - Riveting
  - Setting
  - Raising
- Scrapers
- Nippers
- Grooving Tools
- Rivet Sets
- Steel Square
- Dividers
- Tinner's Steel Rule
- Cutting Nippers
- Flat Files
- Trammels
- Calipers
- Vises
- Benches
- Punches
  - Prick
  - Solid
  - Hollow
  - Lever
- Wire Chisels
- Scratch Awls
- Soldering Coppers
- Wire Gage

Fig. 52—A sheet metal ware shop.

34. Printing.—Only the smaller items of equipment used by these three tradesmen are given. The illustrations show views of the printing departments in which these men work.

Fig. 53—Composing room.

COMPOSITOR

Tools and Equipment

- Composing Stick
- Composing Rule
- Galley
- Tweezers
- Line Gauge
- Copy Holder
- Type, Spaces, Quads
- Tie-up String
- Leads, Slugs
- Bodkin
- Furniture
- Brass Rule
- Cases

STONE MAN

Tools and Equipment

Mallet
Planer
Proof Planer
Quoins
Key
Shooting Stick
Reglet
Furniture
Benzine Brush
Benzine Can
Tweezers
Sponge

Fig. 54.—Stonemen.

Fig. 55—Pressroom.

PRESSMAN

Tools and Equipment

Quoins
Key
Gauge Pins
Mallet
Planer
Type High Gauge
Screw Driver
Knife
Ink Knife
Proof Roller
Wrenches

35. **Bookbinding.**—Bookbinding by laborious hand processes passed out with the advent of labor-saving machines. Today practically the entire book is made by machinery. Only the finest books are hand finished. The arts of tooling, marbling, and finishing require considerable skill, a sense of good design and much patience, but the tools used in this work are generally standard.

Fig. 56—General view in bindery of large printing plant.

HAND TOOLS AND EQUIPMENT FOR FINISHING

Finishing Press
Plow and Press
Scrapers
Press Boards
Gold Cushion
Gold Knife
Protector
Gilder's Tips
Laying-on Screen
Burnishing Tools
Gilder's Hand Tools
Gilding Boards
Gauge
Pallet
Band Creaser
Chase
Dies
Stock Knife
Gouges
Stamps
Finishing Rolls
Shears
Rubbing-up Stick
Pincers
Joint Rods
Straight Edge
Paste Box
Skiving Knife

FOR MARBLING

Color-dropping Machines
Decorating Machine
Whisk Broom
Dip Trough
Brushes
Combs
Rake
Stylus
Skimmer
Clamps

FOR HAND TOOLING

Press
Brush
Creaser
Sewing Frame
Pressing Zinc
Backing Hammer
Folder
Awl

MACHINES AND EQUIPMENT

Skiving Machine
Case-smoothing Rolls
Punching Machine
Crimping Machine
Bundling Machine
Mail-wrapping Machine
Index-cutting Machine
Perforating Machine
Numbering Machines
Case-making Machine
Book Compressor
Trimming Machine
Gumming Machine
Covering Machine
Casing-in Machine
Beveling Machine
Roller Backing Machine
Case Gauge
Moulding Iron
Sewing Machine
Table Shears
Folding Machine
Standing Press
Tab Cutters
Paper Drill
Gatherer
Wire Stitchers
Paper Cutter
Trucks
Tables
Cabinets
Baling Press
Glue Heater

36. Photo-Engraving.—This is a progressive craft. Improvements in tools and machines have been rapid and constant in the last decade. This trade requires a corps of specialists, among such are the Engraver, Photographer, Plate Developer, Etcher, etc. The trade set below includes tools and machines for the entire establishment.

HAND TOOLS

Reducing Glasses
Retouching Glasses
Magnifiers
Squeeges
Trays
Hand Rollers
Ink Knives
Pliers
Snips
Brushes
Punches
Hammers
Points and Needles
Blocking Hammer
Scrapers
Chisel Gravers
Trimmer
Burnisher
Lining Tools
Draw Tool
Angle Tint Tools
Air Brush
Stencil Knife
Lettering Pen
Blocking Slab
Screw Driver
Combs
Roulettes

Fig. 57—Blocking.

MACHINES	EQUIPMENT
Cameras	Copy Stand
Camera Stand	Negative Rack
Lamps	Dryer
Scales	Retouching Desks
Etching Machine	Plate Washer
Etching Tubs and Rockers	Thermometers
Shading Machine	Hygrometers
Compressing Outfits	Bottles
Proof Press	Pitchers
Routing Machine	Funnels
Beveling Machine	Silver Baths
Sawing Machine	Printing Frames
Trimmer	Powder Box
Guillotine Cutter	Drawing Outfit
Jig Saw	Cabinets
Bending Machine	Gelatine Apparatus
Soldering Outfit	Plate Preparation Table
Shaving Machine	Drying Oven
	Card Cutters

37. Electrotyping.—Most of the electrotyping is done by the wax moulding process, although the larger electrotype founders are also prepared to do lead moulding. Practically all shops are equipped for making nickeltypes as well as electrotypes, the principal additional equipment necessary being the nickel depositing tank. For the lead moulding process, a special heavy moulding press is required, and the mould is made on a sheet of lead instead of a wax case. The operations of depositing the shell, backing, finishing, etc., are practically the same as in the wax moulding process.

HAND TOOLS			
Wax Scrapers	Soldering Furnace	Dividers	Micrometer
Wax Strainers	Branding Tools	Screw Driver	Vise
Bench Shears	Blow Pipe	Comb	
Iron Ladles	Finisher's Tools		
Skimmers	Chisels	MACHINES	
Quoins and Keys	Straight Edge	Washing-out Apparatus	Trimmer
Shooting Stick	Calipers	Wax Shaving Machine	Router
Mallets	Smasher	Black-Leading Machine	Boiler
Planers	Lining Gauge	Stopping-out Machine	Agitator
Brushes	Hammers	Sweating-on Apparatus	Water Still
Bellows	Rule	Straightening Machine	Furnace
Galleys	Saws	Sandpapering Machine	Wax Kettle
Palette Knives	Type High Gauge	Scrubbing Machine	Wax Table
Hand Rollers	Rubber	Case Filling Table	Molding Press
Cutters	Gravers	Beveling Machine	Force Pumps
Soldering Tools	Burnisher	Planing Machine	Jig Saw
		Shaving Machine	Bench Drill

Type High Planer
Backing Pan
Sawing Machine
Notching Machine
Plate Bender
Proof Press
Depthometer

EQUIPMENT

Wax Case-Warming Cabinet
Moulder's Table
Form Racks and Trucks
Dynamo
Anodes
Depositing Tank
Hot Water Tanks
Sinks
Acid Tanks
Finishing Plates
Make-up Table
Cabinets

Fig. 58—A routing machine.

38. Brick and Tile Making.—In this industry, practically all work is accomplished by machinery. Very few hand tools are required. These are used by the molders.

MACHINES AND EQUIPMENT

High Line
Ore Slide
Crusher
Conveyor
Crushing Roll
Bins
Pan Charger
Wet Pan, with steel rollers
Slacking Tubs, with rotating paddles
Mud Buggy
Steel Trestle
Mud Tank
Molds
Pallets
Templates
Rack Car
Drier Tunnels
Kilns
Wheel Barrows
Machine Shop
Electric Motors

—For Clay Brick and Tile Add—

Pug Mill
Wire Wheel
Repress

HAND TOOLS AND EQUIPMENT

Form Molds
Paddle
Shovel
Steel Brush
Whisk Broom
Scrapers
Trowels
Sand Box

39. Paper Box Making.—This is an industry in which practically all work is accomplished by machinery. The specialist here, the Die Maker, requires considerable skill and ingenuity to plan and execute special jobs as they come to the shop. His equipment is listed here.

The Gluer is a complicated machine. It receives the paper, glues and folds it, counts each, and delivers boxes ready for packing.

MACHINES AND EQUIPMENT

Printing Presses
Color Presses
Electrotypes
Ink Mixer
Ink Scales
Paper Cutters
Galley Presses
Dies
Baler
Treating Machine
Ironer
Cylinder Cutting Presses
Waxing Machine
Cutter
Wire Stitcher
Punching Machine
Gluing Machine
Scales
Trucks
Racks
Inks
Putty Knives
Safety Cans

Fig. 59—Making boxes by hand.

TOOLS AND MACHINES FOR DIE MAKING in connection with box making.

News Cases, with necessary type and equipment
Scroll Saw
Trimmer
Saw Bench
Hand Bending Machines
Lead Cutter
Brass Rule
Steel Rule
Hammer
Mallet
Type Planer
Quoins
Chases
Cork Squares
Laminated Stock

40. Wall Paper Printing.—The printing of wall paper is accomplished mainly by special machines. The principal one is, perhaps, the Printing Machine, which prints the several colors, dries the inks, and rolls the paper,—all in one continuous operation. Block Cutting is a highly specialized trade within this industry. It consists entirely of hand work and requires very special tools.

MACHINES

Scales
Border Cutting Machines
Rolling Machines
Hand Cutter
Numbering Machines
Sample Book Rack
Pulling-in Machines
Power Cutters
Stitchers
Boats
Elevating Trucks
Grounding Machines
Color Mixing Machines
Printing Machines
Engraving Machines
Embossing Machines

EQUIPMENT

Sample Book Table
Color Vats
Barrels

Paddles
Drying Racks
Conveyor
Bundling Horses
Machine Shop

HAND PRINTING EQUIPMENT

Flat Block
Hand Press
Slush Box
Brush
Slicker
Color Box
Special Brush

BLOCK CUTTING TOOLS

Drawing Instruments
Brass Rolling Machine
Snips
Special Hammers
Special Bending Pliers
Special Cutting Pliers
Special Gouges
Gauges
Files
Guillotine
Anvils
Emery Wheel
Grind Stone
Shape Drawing Plate
Vises
Gouging Iron
Forming Chisels
Turning Lathe

41. Leather Tanning.—Leather tanning is an extensive industry, but requires very few hand tools. The bulk of work is accomplished by special machines.

MACHINES AND EQUIPMENT
(For Upholstery Leather)

Fat Scrapers
Lime Vats
Unhairing Machine
Fleshing Machine
Chemical Vats and Appliances
Tanning Vats and Pivoted Frames
Rocker Vats
Wringing Machines
Stoning Machine
Splitting Machine
Paddle Wheels
Scouring Machine
Sumac Boxes
Wet Tacking Frame
Softening Machine
Japan Shop Frame
Embossing Machine
Measuring Machine
Drying Oven
Oils
Lime
Sumac
Pigments

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Fig. 60—Unhairing machine.

HAND TOOLS

Steel Slicker
Brushes
Cork Armboards
Sponges

SECTION FOUR

OPERATIONS

by

CHARLES W. SYLVESTER,

Director of Pre-Vocational and Vocational Education,
Hammond, Indiana.

OPERATIONS

1. In mechanics, the things from which objects are made are classed as materials, the things used as agents in shaping the materials are called tools, and the methods by which the materials are shaped with tools are called processes or operations. Thus tools and operations are closely related. However, a tool which enables a process to be carried out in one material may not function in another material. For example, the process of "squaring up" a wooden beam, an iron bar or a piece of stone requires different tools.

To present processes without reference to tools would leave the discussion incomplete, and to discuss tools without processes might leave one with no idea of the proper procedure in actual work. To discuss the two concurrently, placing emphasis upon the use, manipulation and care of tools is the aim of this section. Each trade uses primarily a certain kind of material, and the common processes under each trade are given. In cases where a process is the same and tools are used in the same way in more than one trade, reference is made to the explanation first given and repetition is thus avoided. A careful study of this section should give an intelligent understanding of how men in various producing industries proceed with their work. It should assist one in deciding whether a certain line of work would appeal to his interest and whether it covers processes for which he has ability.

SAW MILLING

2. **Band-Sawing.**—Band-sawing is one of three methods of sawing logs into lumber. See Fig. 1. The other two methods are circular sawing, and gang-sawing. Band-sawing is gradually displacing the other methods because it makes a narrow saw kerf as compared to the others and cuts very rapidly. Large band-saws made with teeth on both edges saw logs both on the forward and return trips of the carriage.

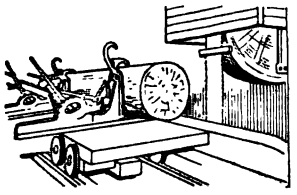


Fig. 1.

After logs are inspected for spikes and stones they are thrown or pushed to the log deck and from there to the log-carriage. A log is fastened on the carriage with iron hooks called "dogs". After the carriage is set, it moves forward and the saw cuts off a "slab". If a board is not to be cut on the return of the carriage, the log is moved back so that it returns without touching the saw. In this manner two or three boards are sawed. Then, the position of the log is changed and a like number of boards

are cut from the opposite side. Next, it is given a quarter turn which brings it face down on the carriage. Fastened in this position, all but a few boards are sawed; it is then given a half turn and the sawing completed.

3. **Circular Sawing.**—In circular sawing, two saws are generally used, one being placed directly over the other. For small and medium sized logs, the top saw is not used. The waste from a circular saw is large because of the wide kerf which it makes. See Fig. 2. The method of handling a log in circular-sawing is the same as in band-sawing.

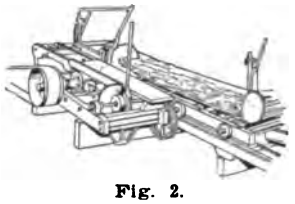


Fig. 2.

4. **Gang-Sawing.**—Gang-sawing cuts several boards at a time. A gang-saw consists of a number of straight blades fixed in a vertical frame which can be adjusted to suit the job. Special gang-saws are used for cutting standard sizes of boards and timbers.

5. **Plain Sawed** boards, which are cut parallel to each other through the entire log, are called "slash sawn". See Sec. 2, Art. 25.

Quarter Sawed lumber is usually cut by first quartering the log or by cutting a few boards through the center and then cutting from quarters of the log. The log is held on the carriage in the proper position and the sawing is done in the ordinary manner. See Sec. 2, Art. 26.

6. **Edging.**—Many of the boards when cut from a log have rough edges. These edges can be made parallel and square by running the boards through an edger. See Fig. 3. In small mills, an edger, consisting of one saw, is used, but for speed and accurate work a gang edger, consisting of two or more saws in the main frame of the machine is employed.

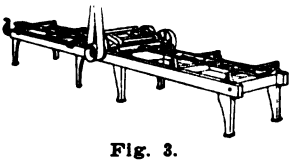


Fig. 3.

7. **Trimming.**—A trimmer or cut-off saw is used to trim the ends of the boards square and to the proper length. See Fig. 4. In large mills, a "jump saw" is used for cutting boards to length and it can be set to cut at any desired length. Usually, lumber is trimmed 1 inch longer than the specifications so that it may be trimmed again, if necessary. Thick timbers are trimmed with a "butting saw."

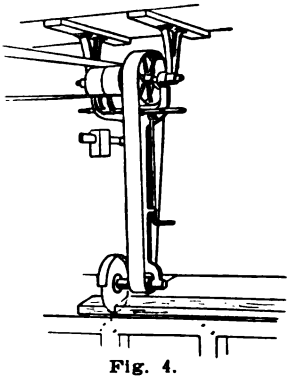


Fig. 4.

PLANING MILL WORK

8. **Surfacing.**—After lumber has been sawed at the mill, and seasoned, it is received by the planing mill in a rough condition. There it is passed through a planer and surfaced or dressed to a standard thickness. It is necessary to pass a board through a single cylinder surfacer twice, but in going through a double cylinder surfacer both sides are dressed with one operation. See Fig. 5. Most surfacers used in a mill are a combination planer and matcher, in which the jointing as well as the surfacing is done. A timber sizer which will surface four sides at the same operation is used in dressing timbers to size.

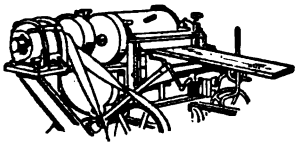


Fig. 5.

9. **Jointing.**—Boards that are not jointed at the time they are dressed must be edged on a jointer or on a special machine. Machine jointing is done for special jobs in cabinet work such as making glue joints and other work requiring true, straight edges. The rear table of the jointer is set level with the knives. The front or working table is adjusted according to the cut desired. See Fig. 6. The adjustable bevel gauge should be set at the proper angle with the face of the table to give the desired angle to the edge of the board. For a right angle, it should be tested with the try-square, and with the bevel for any other angle. Although some gages are graduated in degrees, it is well always to test the angle. The left hand is used to hold the board against gage and face of the jointer while the board is pushed forward with the right hand. The jointer can be used for rabbeting, and, when fitted with special cutters, it can be used for beading, moulding and grooving.

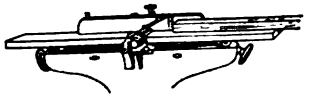


Fig. 6.

10. **Resawing.**—Band and circular re-saws are especially constructed for re-sawing, being fitted with adjustable roller guides and feed works. The rolls are usually self-centering, and in use the right hand set is made rigid while the left hand rolls are elastic so as to hold uneven stock firmly against the rigid rolls as it is sawed. Attachments for re-sawing light wood can be put on the average saw. The rolls should be adjusted to suit the work, tested for correctness, and the lumber fed into the saw. Re-sawing is done in all hard and soft woods in planing mills, box factories and furniture plants. It is used

to re-saw boards, cut veneer from timbers, make bevel siding and weather boarding, and other work of a similar nature.

11. **Ripping.**—Lumber is generally ripped on a circular rip-saw. A planing mill usually uses a self-feed machine, while in a general wood working shop a plain rip saw or a universal saw bench is used for ripping. See Fig. 7. A power fed gang ripping saw is used for ripping heavy lumber in two or more places at the same time. For ripping on the self-feed saw, the gage is set at the desired distance from the saw, the feed rolls adjusted to suit the thickness of the lumber, and the board started through between the feed rolls above the table and the idler rolls in the table. Many ripping machines are equipped with a number of saws for narrow strip ripping.

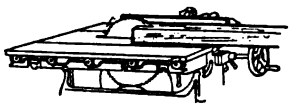


Fig. 7.

12. **Cut-Off Sawing.**—Cutt-off sawing can be done on a saw bench, but ordinarily where a number of pieces are to be cut to the same length, as in furniture, sash, door, and box work, a special cut-off saw is employed. Cut-off saws are arranged for either single or double cutting. The saw or saws are first properly adjusted. A board is placed on the carriage against the gage set for the proper length and it is moved into the saw which then does the cutting. A swing saw is used where it is more convenient to hold the lumber stationary. The board is held firmly against a fence, at right angels to the face of the saw, with one end against a properly set stop. The saw is swung forward, cutting through the wood. See Fig. 4.

13. **Band-Sawing.**—Curved designs on wood may be cut out on a band-saw. A band-saw can be used for ripping but the results are not very satisfactory. To cut a curve at right angles to the face of the board, the saw table is set at right angles to the saw blade. The saw guide is adjusted to within a short distance of the work, and after the saw is moving, the curve is cut, moving the wood carefully and gently against the saw. To saw at an angle, the table is set at the same angle with the saw as the one to be cut. See Fig. 141.

14. **Sanding.**—Hand sanding on all kinds of woodwork has been largely displaced by the machine sander. Sanders are built for all types of work and the four principal types of machine sanders are the belt, disc, spindle and drum. Drum sanders are built for hand or self feed. The hand drum sanders have one drum covered with

sandpaper, over which wood is pushed by hand. They are convenient for small surface work. The self-feed sanders, having one or more cylinders, are arranged and operated very much like surfacers. The board or timber is fed into the machine and comes out sanded. A machine with two cylinders has one cylinder for rough sanding and one for finishing. Self-feed drum sanders are for flat work and should be adjusted to suit the thickness of the pieces. An exposed drum sander is used for both flat and bent woodwork. Disc and spindle sanders are small machines used for sanding small work in cabinet, pattern, furniture and other woodworking shops. Scrolls, curves, brackets, irregular and surface work can be smoothed on these machines. The wood is fed by hand and the smoothness obtainable depends on the grade of sandpaper used. A belt sander is used in planing mills, factories, box plants, etc. It is used upon both flat work and assembled furniture. The belt is held against the surface to be sanded with a special hand guide. See Fig. 8.

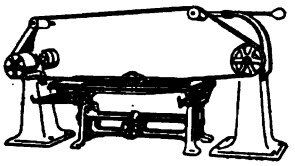


Fig. 8.

15. Moulding, Sticking, Tenoning, Mortising, Boring, Dovetailing, Paneling, Shaping, Doweling, Rabbeting, Turning and **Clamping** work may be done with special machinery, much of which is automatic. The operation of each machine requires special instruction. Care must be exercised in setting machines and making adjustments for work. Cutters should be kept sharp and a machine well oiled when in use.

CARPENTRY*

16. Use of the Try-Square.—For testing the accuracy of right angles, squaring up stock, testing the width of work and scoring lines at right angles across surfaces, the try-square is used. A try-square having an eight inch blade is most convenient for general purposes. After the surface of a board is planed smooth and flat, it is tested both across and with the grain in several places, the blade of the try-square being used as shown in Fig. 10.

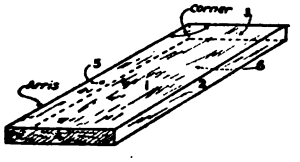


Fig. 9—Illustrating terms Applied to a board: 1 and 6, faces; 2 and 5, edges; 3 and 4, ends.

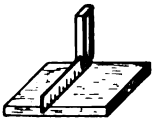


Fig. 10.

*Note.—Some of the common joints used in carpentry construction are included in list of joints under Furniture and Cabinet Making.

In testing work for squareness, the head of the try-square should rest firmly against a finished surface of the work with the blade touching the edge being tested. The try-square is moved along the work and the edge tested at a number of places. See Fig. 11. In squaring the end of a piece of work, it is tested with the head of the try-square, first against the working face, and then against an edge which has been squared. When finished, the end should be at right angles to both the working face and working edge. See Fig. 12. When cross lining, the point of a knife is placed where the line is desired and the try-square is slid along with its head pressed firmly against the adjacent surface until the blade reaches the knife point. Then the line is scored. See Fig. 13. Uniformity of width or thickness of a board is determined by placing the head of the square against one surface and sliding the square along, at the same time watching for variations. Corners of assembled work may be tested with the try-square as shown in Fig. 14.

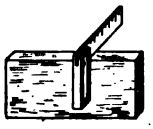


Fig. 11.

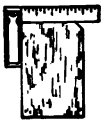


Fig. 12.

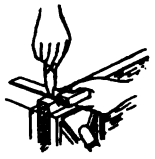


Fig. 13.

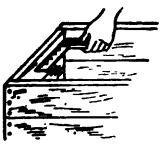


Fig. 14.

17. Laying Out Angles with T-Bevel.—The adjustable blade of the T-bevel permits any angle to be laid out and tested. It may be set to any angle either by first laying out the angle on a smooth surface, by using a protractor, by means of drafting triangles, or from graduations on a framing square. To set the blade to a 45 degree angle by a carpenter's steel square, the head of the T-bevel is placed against one inside edge of the square and the blade adjusted until its edge is equally distant from the corner of the square on both blade and tongue. Drafting triangles may be used in setting a T-bevel to any angle given on them. See Fig. 15. When properly set, it is used similarly to the try-square. (See directions for laying out other angles in "The Steel Square" by Hodgson.)

Fig. 15.

18. Testing Angles with T-Bevel.—When the T-bevel is set, the blade is firm. In this condition it may be used for testing work from time to time. A chamfer or beveled edge is tested by sliding the T-

bevel along the surface in the same manner that a working edge is tested with a try-square. Angles are tested for accuracy with the inside edge of the T-bevel blade against the surface being tested, and the beam against the adjacent surface. See Fig. 15.

19. **Use of Miter-Box.**—Wood may be cut at any angle by laying off the angle with a T-bevel or miter-square and sawing to the line, or more accurately, by the use of the miterbox. The best miter-boxes are made of metal and the saw can be adjusted instantly to any desired angle. See Fig. 16. Wooden miter-boxes may be made as shown in Fig. 17. Such a box provides only for cutting a piece square across, or at an angle of forty-five degrees. As these two angles are most commonly used, this kind of miter-box is convenient. Care must be exercised in making a miter-box to get the angles accurate. Before using a miter-box, it should be fastened to a bench. The saw should not be allowed to cut into the box carelessly.

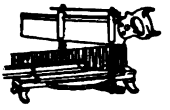


Fig. 16.

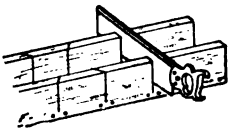


Fig. 17.

20. **Using the Miter-Square.**—The miter-square has the blade fixed at an angle of forty-five degrees. This is the most common angle used in joint work outside of the right angle. The miter-square is used in a similar manner to the try-square. See Fig. 18.

Fig. 18.

21. **Using the Steel-Square.**—The steel-square is used as a straight edge, Fig. 19, and in squaring large stock, but its chief use is in framing or roof construction, Fig. 20. The T-bevel may be set from a steel square or an angle may be laid off directly on the work, as

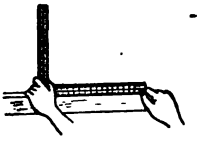


Fig. 19.

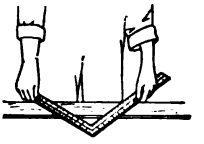


Fig. 20.

in Fig. 15. There are a number of graduations and tables on the steel square, which, when understood, make it a valuable tool. For example, the Essex Board Measure is a very useful table in finding the board feet in a board. The figure 12 on the outer edge of

the table represents a 1″ board 12″ wide and is the point from which to start in using the table. For a board 1″x8″x10′, under the figure 12 (just mentioned) locate 10, the length of the board. The figures under the width of the board (8) and directly opposite the number 10 give the board feet in the board, namely 6 8/12 board feet. See Fig. 21. To understand other methods of measuring as laid out on different squares, books which describe the steel square in detail should be studied. An instruction book generally accompanies a new square. This book explains the various tables on the square, tells about laying-out rafter cuts, etc.

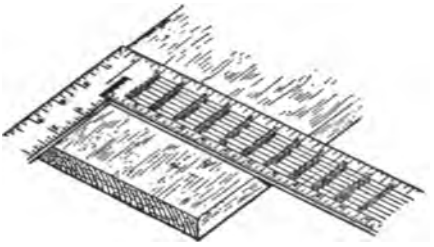


Fig. 21.

22. Use of the Spirit Level.—The level has largely replaced the plumb bob in the carpenter's equipment. In building work, the level is necessary, though seldom used in the cabinet shop. A large surface is leveled by placing a long straight edge on the surface and testing with the level on the straight edge. On small pieces, only the level is used. See Fig. 22. If the surface being tested is level, the bubble will come to rest at the middle of the glass marked by cross lines. In general, the longer the level, the more accurate it is. For vertical testing, a plumb-bob may be attached to the level, or if the level has an end glass, the reading may be made from it. See Fig. 23.

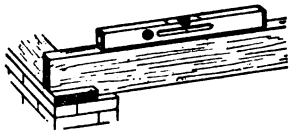


Fig. 22.

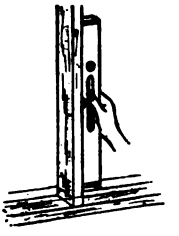


Fig. 23.

23. Use of Bench-Hook.—Small stock is held best on a bench-hook while performing such work as sawing, block-planing and sandpapering. The bench-hook prevents vibration of the stock, yet allows it to be moved readily. It aids in producing neat, accurate work and saves the bench from being marred. Fig. 26 shows the proper position of the bench-hook, stock and hands in sawing. When block-planing, the opposite end of the bench-hook is used. The working edge of the stock is placed against the block and

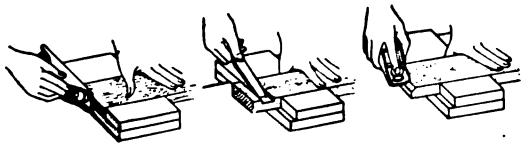


Fig. 24.

the end to be planed is held flush with the edge of the bench-hook. The left hand holds the work. The right hand holds the bottom of the plane against the bench-hook and work, in which position it is pushed back and forth until the end is square. See Fig. 24. When chiseling or beveling, the stock is held on the bench-hook as in sawing. See Fig. 24.

24. Cross-Cut Sawing.—Sawing across grain is called cross-cut sawing. Back saws are cross-cut saws, but the term cross-cut saw, as commonly used, refers to a hand-saw having the teeth filed for cutting across the grain of the wood. Sawing may be done either on a saw-horse or at a bench. For large stock, the saw-horse is preferable. Fig. 25 shows the board, saw and body in position for using the cross-cut saw. The saw is held in the right hand and guided by the thumb of the left hand, held against the side of the saw. The cutting edge of the saw should be held at an acute angle to the surface of the board and the cut started on a back stroke. Gradually increase the stroke to the full length of the saw. The weight of the saw should furnish all the pressure necessary to cause it to cut. The sides of the saw should run at right angles to the surface of the board. The saw kerf should follow the line. If the saw kerf tends to leave the line, it may be brought back by taking short strokes and gently twisting the blade in the direction it should go. This is often necessary in rip sawing. In sawing, a long even stroke should be used. It is not tiresome, cuts fast, and gives a smooth even cut. A short jerky arm and shoulder motion gives a rough, irregular cut and is tiresome.

Fig. 25.

25. Back-Sawing.—Back-sawing is practiced where careful work is required, usually upon small materials. A straight, smooth cut can be made because the saw has a rigid back, the teeth are small and have very little "set." Before cutting a board with the back saw, the stock is scored entirely around with a sharp knife, guided by the try-square. Then the piece is placed on a bench-hook and held in position with the left hand. See Fig. 26. In starting to cut, the saw is guided by the thumb of the left hand, held against the side of the saw. The saw is moved backward and forward its full length, touching lightly the back edge of the piece. Gradually the saw is lowered, thus cutting farther into the stock until the kerf extends entirely across the surface. There should be no material left between

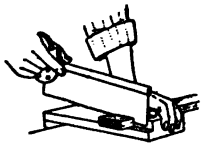


Fig. 26.

the kerf and the knife line, but the saw should neither cut nor roughen the line. The kerf should always be in the waste stock. The lines down the edges are followed the same as across the face.

26. Rip-Sawing.—Sawing with the grain is called rip-sawing. A rip-saw has teeth filed with the cutting edge at right angles to the sides of the blade. See Art. 81. Material for ripping may be fastened in the vise or placed on the saw-horse. The latter method is better for large stock. Fig. 27 shows the saw, stock and body in proper position for using the rip-saw. The rip-saw is used in a similar manner to the cross-cut saw. If the saw binds in the wood, a small wedge driven into the saw kerf, back of the saw, will stop the gripping. In careful work, when ripping stock, allowance must be made for planing to the line.

Fig. 27.

27. Compass Sawing.—A compass saw is a narrow, pointed saw having wide set teeth, by which curves may be sawed easily, as the narrow blade permits the saw to turn readily in the wide kerf made by the teeth. See Fig. 28. A compass saw is used both across and with the grain of wood, thus making it possible to saw a complete circle. If the curve is very sharp, the point of the saw where the blade is narrow is used. The compass saw is used on straight line work where there is not room to start a hand saw and for such work as shown in Fig. 29.

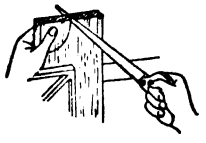


Fig. 28.

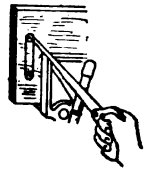


Fig. 29.

28. Use of the Coping Saw.—The coping saw is used to saw curves in small, thin stock. See Fig. 30. Coping saw blades are highly tempered and fragile, so care should be exercised in sawing. Most coping saw work is done with the wood resting horizontally on the bench and held in place with the left hand. The teeth of the blade should point towards the saw handle. When the vise is used to hold the wood, the saw teeth should point away from the handle. The saw blade is held perpendicular to the material. Slight pressure is applied, and the cut made with the entire length of the blade.

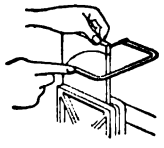


Fig. 30.

29. Using the Turning Saw.—For cutting curves in stock larger and heavier than can be handled with the coping saw, the turning saw is used. See Fig. 31. The saw may be used to cut, either by pulling it

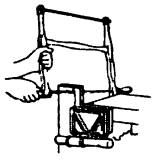


Fig. 31.

towards the body, or by a pushing stroke. As a rule, the former is the better method. The saw frame is held with both hands near the blade. The course of the saw blade is changed by revolving the blade in the frame, but care must be taken that the blade is not twisted. While sawing, the frame should be kept at right angles to the surface of the board. In sawing a curve which is entirely inside a piece, the saw blade must be removed from one handle and put through a hole bored in the waste part of the stock. Then the blade is fastened to the handle, adjusted, and the sawing done. See Fig. 32. As the cut is likely to be rough, enough stock must be allowed to smooth the piece.

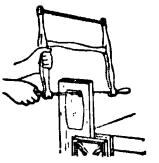


Fig. 32.

30. **Use of Jointer-Plane.**—The jointer-plane is from 28″ to 30″ long and is similar to the jack-plane, except that it is longer. The long plane bottom enables stock to be jointed readily, for only the high places are removed until the surface is level. For method of using, see Fig. 33. The average carpenter has either a jointer-plane or a fore-plane but not both.

Fig. 33.

31. **Use of the Fore-Plane.**—Fore-planes are short jointers from 22″ to 26″ long and are used chiefly for straightening stock in making joints. The length of the plane bottom permits the plane bit to cut only high places on a surface. The plane bit should extend only slightly, and should be laterally adjusted to cut evenly. By sighting along the plane bottom, the workman can see that the cutter is properly adjusted. In planing, the entire length of the plane bottom is kept flat on the work. The fingers of the left hand are held as in Fig. 34, and serve as a guide to keep the plane bottom on the work.

Fig. 34.

32. **Use of the Jack-Plane.**—The jack-plane is used where considerable material is to be planed away. In many shops the jack-plane is used for most planing work, and for such work the bit is ground straight, with the corners slightly rounded, as in the fore-plane. In setting the plane-bit, the fingers should not be passed over the bottom of the plane. It should be held up with the left hand, and sighted along the bottom from the toe until the proper adjustment is made. The fingers of the right hand are used to make the ad-

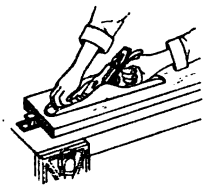


Fig. 35.

justments. By means of the lateral adjusting lever, the plane bit may be extended evenly through the mouth. The cap iron can be moved back from or close to the cutting edge of the plane bit, depending upon the kind of wood and the thickness of the shaving desired. Fig. 35 shows a jack-plane used as a smoothing plane. Moreover, it is often used as a jointer.

33. **Use of the Smooth-Plane.**—The surface of a board should be true before the smooth-plane is used. This plane will smooth a surface without truing it. The cap iron of a smooth plane should be set very close to the cutting edge, and, for fine work, the plane should be set to take shallow cuts. No wood, ordinarily used, is so close grained or knurled that it cannot be smoothed, if a properly sharpened and adjusted smooth-plane is used. The plane bit should be so sharpened and adjusted that it will take a thin, flat shaving, almost the entire width of the blade. To secure a smooth cut, the grain of the wood must be followed carefully. The proper position for planing is facing the work, standing at one side and slightly back of the place where the planing is to be done. In planing, a firm, steady, downward and forward pressure is used. At the beginning of the stroke, as the plane enters on the board, the most weight should be upon the toe of the plane and at the end of the stroke, as it leaves the board, upon the heel. This keeps the surface true. The plane should be held firmly and not allowed to jump or chatter. In drawing the plane back, its heel should be lifted so the bit will not be dulled. See Fig. 36.

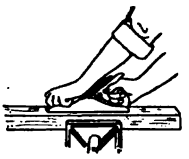


Fig. 36.

34. **Block-Planing.**—Block-planing is usually done on pieces which cannot be taken to a vise. The plane is small and can be used with one hand, leaving the other hand free to hold or steady the material. The block-plane is principally for use on end grain where the adjustable throat and low angle of the blade make it possible to cut very fine shavings. In planing end grain, splintering the edge of the work may be avoided, either by planing towards the middle of the piece from both edges, by chamfering off the corner of the back edge (as shown in Fig. 37), or by using a bench hook or block to support the back edge. See Fig. 24.

Fig. 37.

35. **Circular Planing.**—After the desired curve is laid out on a smooth surface, the flexible steel face of a circular plane is adjusted

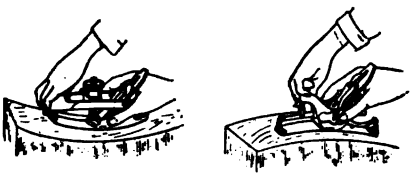


Fig. 38.

to this arc. This may be done by laying the plane on its side and adjusting it until the plane face is parallel to the arc laid out. The plane bit is set square with the face and not too deep, to prevent tearing and roughing the wood. Planing should not be done against the grain. By reversing the piece of work, it may be planed at all times either with or directly across end grain. Fig. 38 shows plane strokes completed. Both convex and concave arcs may be planed with a circular plane.

36. Rabbet Planing.—A rectangular notch cut lengthwise in the edge of a piece of wood is called a rabbet. To cut a rabbet, the rabbeting plane is so set that it can cut only the desired sized rabbet. After adjustments are made on the plane for width, depth and location, the most care required is in holding it properly. See Fig. 39. The plane is held firmly against the wood without tipping it sidewise and even cuts are made the entire length of the rabbet desired.

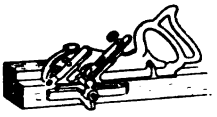


Fig. 39.

37. Router Planing.—To smooth the bottom of a groove or dado, the router-plane may be used. Dadoes, grooves and panels may be cut with this plane, but the cutter must be lowered for each successive cut. See Fig. 40.

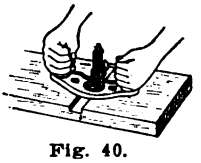


Fig. 40.

38. Dado Planing.—In cutting grooves, or dadoes, across the grain of wood, a dado plane may be used instead of a saw and chisel. Fig. 41 shows a dado plane in use. The stock is fastened on the bench and a strip called a fence is fastened across the stock to guide the plane. The plane has two cutting spurs, one on each side of the plane bit. These spurs score the wood, cut the fibers and prevent the plane bit from tearing the grain.

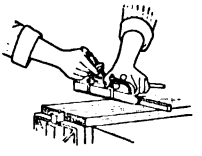


Fig. 41.

39. Use of the Moulding Plane.—The moulding plane is used for cutting mouldings. Various forms can be made by using different plane bits. See Fig. 42.

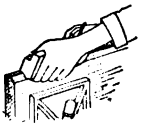


Fig. 42.

40. **Use of the Universal Plane.**—A universal plane will do the work of a number of planes, as the beader, rabbet-plane, dado plane, plow, matching plane, sash-plane, and moulding plane. The variation in cutters, together with depths and widths which can be cut, give this plane a wide field of usefulness. See Fig. 43. When properly equipped, set and adjusted, it is used similarly to any special moulding plane.

Fig. 43.

41. **Use of Draw Knife.**—A draw knife may be used for roughing out work and cutting curves on narrow surfaces where the waste is too much to be planed. The stock is held in the vise and the draw knife pulled toward the worker, either with a straight or sliding cut. Care should be used to prevent deep cuts as it is likely to follow the grain. If necessary, the piece is reversed and cut the other way. See Fig. 44.

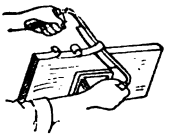


Fig. 44.

42. **Use of the Spokeshave.**—The spokeshave is used in working on curved surfaces, such as handles, concave and convex edges, etc. See Fig. 45. A spokeshave is similar in principle to the plane. However, it has a short bearing surface and is controlled by two side handles. It should never be used where a plane will do the work. It may be pulled or pushed at the convenience of the worker. The blade should be adjusted to cut from heavy to light shavings as the work is finished.

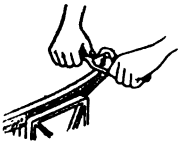


Fig. 45.

43. **Use of the Scraper.**—The scraper is used to make a surface smoother than usually can be done with the plane. It is held as shown in Fig. 46 with the blade inclined from the body at an angle which will allow the edge to cut well. To cut, it is pushed forward, and at the same time downward pressure is applied. To pull it, the angle at which it is held is reversed. Scraping should be done with the grain of wood, and, to make the scraper cut a deep shaving, it is bowed by pressing on the center with the thumbs. Work is tested for smoothness with the finger tips. A scraper is sometimes set in a frame with handles and is then called a veneer scraper. This kind of scraper permits faster work and the bottom of the scraper keeps the blade at a uniform angle.

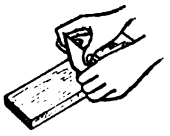


Fig. 46.

44. Chiseling.—There are two methods of cutting with the chisel, the straight cut and the shearing cut. Fig. 47 shows the straight cut, the tool being moved squarely into the material. Fig. 48 shows the shearing cut. The chisel is moved forward with its cutting edge at an angle to the direction of the cut. The shearing cut requires less force than the straight cut and more delicate work can be done by this method.

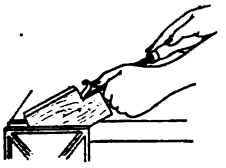


Fig. 47.

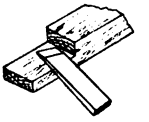


Fig. 48.

45. Paring with the Grain.—To pare a surface flat and smooth, the chisel is held so that the flat side next to the wood acts as a guide. See Fig. 47. The chisel should be used with the bevel next to the wood, when a quantity of shavings is to be cut away quickly. The cutting edge should be sharp and care exercised to leave the surface smooth. No mallet is used in paring with the grain, and no force is needed other than that exerted by the hands. Stop chamfers and flat surfaces, where a plane cannot be used, are made by this method.

46. Paring Across the Grain.—More force is required to cut the fibers of wood when cutting across the grain. The wood should be clamped in a vise leaving both hands free to use the chisel. Thin cuts should be taken alternately from each edge of the piece. The chisel is held in the same manner as in paring with the grain, and is pushed directly across the grain. See Fig. 49. In the dado cut, the chisel should incline towards the saw kerf making V cuts and leaving the ridge in the center of the dado, which is removed later.

Fig. 49.

47. Paring End Grain.—The face of the piece of work should rest on a flat surface of waste wood in chiseling end grain. This will prevent splintering along the lower arris. It is often necessary to clamp the piece of work. The chisel, held perpendicularly, should be guided by the thumb and first finger of the left hand and pushed downward with the right hand, using a shearing cut. To leave a smooth surface, the chisel must be sharp and little material should be removed at a time. The piece may be held upright in the vise while chiseling round corners. A shearing cut, made with the grain, is used to prevent splitting.

48. **Mortising.**—In cutting a mortise, the wood should be first removed as far as possible with a bit. See Fig. 50. The chisel, held in the left hand, is then used in cutting to the line and in smoothing the sides of the mortise. It may be tapped lightly with a mallet. The cut should be kept perpendicular to the surface and the material gradually removed to the lines. A through mortise should be cut part way through from each side. In finishing a mortise, the flat side of the chisel should be against the sides of the mortise. See Fig. 51.

Fig. 50.

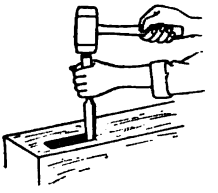


Fig. 51.

49. **Gouging.**—The gouge is similar to a chisel but has a curved blade. Gouges are made with a bevel either on the outside or inside. The outside bevel gouge is the common form and is used on concave surfaces. The inside bevel gouge is used on convex surfaces but is not often needed. A gouge should be pushed with the right hand, being guided and manipulated by the left hand, which holds the blade. See Fig. 52. In delicate work, or in finishing work, the gouge may be guided by the fingers of the left hand across the blade. Long strokes taking thin, even shavings should be used. If the blade is twisted on its axis when pushed forward, this shearing motion will give a smooth cut. In gouging out broad surfaces, it should be used across the grain.

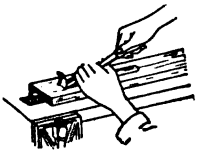


Fig. 52.

50. **Clamping.**—All clamps are alike in principle but have been adapted to different kinds and sizes of work. The object of a clamp is to force materials into closer contact whether it be a flat surface or a several piece column. In most shops, bar clamps are used on large surfaces and hand screws on smaller pieces to make glue joints.

51. **Carpenter's Bar Clamps.**—Bar clamps are used over large surfaces and are capable of exerting heavy pressure, which forces materials into close contact. This allows glue, used in making joints, to form a firm bond between pieces. A joint to be glued is usually matched, splined or doweled. Then glue is spread on the edges and the pieces clamped together. The clamps are applied about twelve inches apart across the surface and tightened until surplus glue is pressed out and a close joint secured. See Fig. 53. In case the pieces being glued tend to buckle, strips across the end, lightly secured with hand

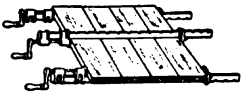
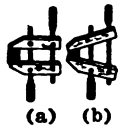


Fig. 53.

screws, will be needed. See Fig. 55. In cabinet work, the joints should fit, before glue and clamps are applied. With clamps, boards may be forced to make a joint, but constant use will cause them to pull apart in time. A good glue joint is easily made, if the planing is properly done, otherwise it is almost impossible. See Art. 115.

52. **Use of Hand Screws.**—The wooden hand-screw is desirable for holding small pieces of wood while planing a chamfer, for holding small pieces together while boring holes and nailing, and for clamping glued work. Clamps with wood jaws do not mar and bruise the surface of the wood as much as iron clamps. Also, their jaws have larger faces, and when properly applied, exert an even pressure over more surface. In placing a hand screw on materials, the middle spindle is tightened against the work, leaving the clamping ends of the jaws a little wider apart than the opposite ends. Then, the end spindle is tightened, thus bringing the jaws parallel and causing even pressure. See a in Fig. 54. A very convenient hand-screw which permits the clamping of angular pieces is shown in b, Fig. 54.



(a) (b)
Fig. 54.

53. **Iron Hand-Screws.**—Iron hand-screws are used for clamping small pieces together in special places. The pressure obtained by bar clamps cannot be obtained by such screw clamps, as the only leverage for tightening the screw is a wing handle. See Figs. 55 and 56. In putting iron clamps on a piece of work, all surfaces and edges not to be removed later should be protected from bruising by scrap blocks of soft wood.

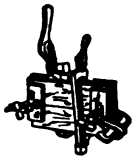


Fig. 55.

Fig. 56.

54. **Use of Braces.**—The brace or bit-stock holds the various bits used in boring, reaming, screw-driving, etc. The ratchet brace differs from the common brace in the addition of an attachment which permits the bit to be turned in either direction. This is necessary where there is not room for the crank to make a complete revolution and where more power is required on the crank.

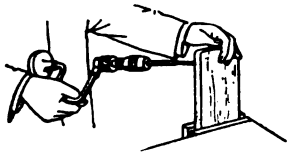


Fig. 57.

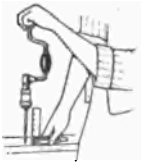


Fig. 58.

In boring horizontally, (as illustrated in Fig. 57), the desired direction of the bit may be determined by use of the try-square, or by sighting from above and

from the side on a level with the bit. When boring vertically, a try-square may be set on the work and the bit lined by it, but one should be able to tell when the bit is at right angles to the work by sighting first from the front and then from the side. See Fig. 58.

Splintering the wood, when a bit goes through, may be prevented by boring through the piece until the point can be detected by the fingers of the free hand, and then boring through from the opposite side. See Fig. 57. Another method to prevent a bit from splintering the wood, is to clamp a soft block of wood back of the piece being bored. This piece will take the spur or screw point of the bit and pull the cutting edge through the wood. See Fig. 59. To bore a hole at any desired angle, the T-bevel is set to that angle and used in lining the bit as shown in Fig. 60.

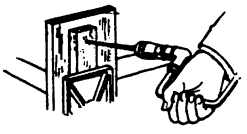


Fig. 59.

Fig. 60.

In boring out a mortise or for inserting dowels, it is often necessary not to bore through the wood. Boring to a certain depth may be gaged by means of a rule or a bit gage. When using a rule, it is held as shown in Fig. 61. By measuring the distance to the chuck as the boring progresses, the exact depth of the hole may be determined. Where a number of holes are to be bored to the same depth, it is more convenient to use a bit gage which bolts over the bit as shown in Fig. 62. Sometimes a block is used to stop the bit at the required depth.

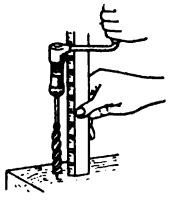


Fig. 61.

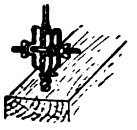


Fig. 62.

55. Use of Bits.—Many kinds of bits are used, the auger bit being commonly used for boring in wood. In boring, the "spur," or screw point, centers the bit and draws it into the wood. The two "nibs" or cutting edges cut the fibers and the "lips" lift the waste wood, which then passes along the twist of the bit to the surface. When much pressure is required to force a bit to enter wood, usually it will be found that the bit is dull. This does not apply to boring in end grain, because in end grain the wood breaks off and will not hold the spur. In boring a deep hole, remove the bit occasionally to carry out the shavings, otherwise they may clog in the twist. To remove the bit, give it one turn back to loosen the spur and then turn forward while lifting the brace. In this manner the shavings will be removed with the bit.

Forstner bits are used to bore into end grain and into wood where the spur of an auger bit would go through when it was not desired. They make smooth holes and do not split the wood.

In boring small holes for screws, nails, etc., the gimlet and twist bits are used. The twist bit is less likely to split the wood.

Expansive bits are generally used for boring large holes. They are adjustable and may be used for boring holes of any size within their limits.

Countersink bits are used for enlarging small holes so the head of a screw or stove bolt will sink into the material. They may be used in either wood or metal. Besides, twist drills may be used in either wood or metal. It is better to use twist bits, than drill bits, in wood, because they are sharpened with a larger angle. Twist bits are too soft to use on metal. Twist drills and twist bits have no spur or lips and must be forced through the work. Care must be used to hold the brace firmly to prevent breaking these bits.

56. Dowel Pointing.—In making a doweled glue joint, it is best to round the ends of the dowels before forcing them in place. This may be done with a knife or similar tool, but a dowel pointer is most efficient. A dowel pointer is held in a brace and with it the dowels may be rounded off or pointed. See Fig. 63.

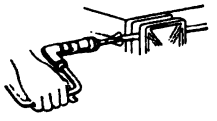


Fig. 63.

57. Driving Screws.—The screwdriver is often misused. It is neither a chisel nor a wedge and should not be hammered into a piece of wood. Neither should a big screw be driven with a little screwdriver. A screwdriver should be selected to fit the screw, and more than one size should be in the equipment. A screwdriver having a blade with a long bevel is best. A short bevel causes the blade to slip out of the screw-slot. A wrench or pair of pliers should not be used on a screwdriver to aid in driving screws. More power can be developed with a long screwdriver than a short one. See Fig. 64.

Fig. 64.

Screwdriver bits are made to fit into braces. The wide sweep of a brace gives more leverage and consequently more power than can be obtained with a straight handled screwdriver. Also, it enables the work to be done more rapidly. See Fig. 65. Using the ratchet and making only part of a revolution helps to prevent the bit from slipping out of the screw-slot.

Fig. 65.

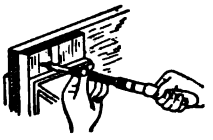


Fig. 66.

A rapid acting screwdriver makes it possible for screws to be driven with speed. With care and skill, it can be used to advantage where time is considered. Fig. 66 shows a very desirable type of screwdriver where much work is to be done.

58. **Gaging Lines.**—To mark a line any certain distance from the edge of a board, the marking gage should be employed. The marking gage may be set by means of the rule as shown in Fig. 67. Where the beam is accurately graduated, the rule need not be used. To mark with the gage, the beam is held with the fingers of the right hand, the thumb being back of the spur. It is tilted forward, and pushed away from the body with the point on the surface to be marked and the head against the working edge, or face of the board. By changing the angle at which the gauge is tipped forward, the depth of the gage line may be regulated. See Fig. 68. In marking a line four or five inches from the edge, the left hand may be employed to hold the beam at right angles to the edge of the board. The spur should be sharpened to a flat sharp edge with the edges at right angles to the beam. A pencil and rule are often used as a marking gage by the carpenter in the manner shown in Fig. 69. By this method, a surface may be lined with reasonable accuracy.

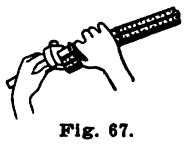


Fig. 67.

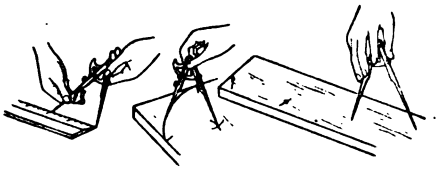
Fig. 68.

Fig. 69.

59. **Mortise-Gaging.**—The mortise-gage is similar to a marking gage, but has in addition an adjustable spur which is set by a thumb screw in the end of the beam. Thus the two points make parallel lines any desired distance apart and any required distance from the edge of the work. See Fig. 70. It should be used the same as the marking gage. In laying out a through mortise with the gage, both sides of the stock are lined, using the same surfaces of the work for gaging each side.

Fig. 70.

60. **Use of the Dividers.**—Dividers, with sharp points, are used for describing circles and arcs (b in Fig. 71), subdividing distances (c in Fig. 71), and for scribing. In setting dividers, the thumb screw binding upon the wing is loosened enough to allow the legs to be



(a) (b) (c)

Fig. 71.

adjusted. See a in Fig. 71. The thumb screw is then tightened and finer adjustment made, if necessary, with the thumb nut on the end of the wing. In describing arcs or circles, the dividers should be held leaning slightly forward, with one leg stationery and the other swung either to the right or left. In stepping off distances, the dividers are swung about each leg alternately and the point set down along a given line. In scribing, one point follows a given line and the other scratches a line parallel to the given line. This method is used on curved and irregular surfaces.

61. Chalk Lining.—In chalk-lining, a heavy cotton line is covered with chalk dust and the dust transferred to the surface to be lined by holding the line taunt against the surface and snapping it. When pulling the line away from the surface, it should be pulled vertically from the place where it is to strike. See Fig. 72. In this manner a long straight line may be made quickly. Chalk-lining is usually used when laying shingles and sometimes when ripping long boards.

Fig. 72.

62. Using a Rule.—A rule divided into one-sixteenth inch divisions is convenient for measuring and laying out work. To mark distances accurately, the rule is placed on edge, with the divisions on the rule touching the wood. In making several small measurements, they should all be marked without moving the rule. A four-fold rule, folding to six inches in length, is convenient to carry. See Fig. 73. A steel rule is most satisfactory for bench work.

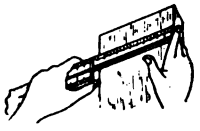


Fig. 73.

63. Making Long Measurements.—The tape line is used for making long measurements. The average tape line for the shop is fifty feet long, graduated to one-fourth inch, and is contained in a metal or leather case. A steel tape is more accurate than a cloth tape. Fig. 74 shows a tape in use.

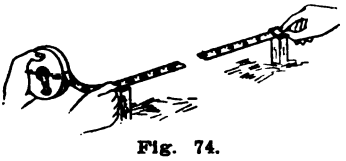


Fig. 74.

64. Measuring Lumber.—For measuring lumber in quantities, the lumber rule is a labor and time-saving devise. To measure a pile of lumber, the metal head of the rule is placed against the far edge of each board with the flexible blade against the surface across the width. Knowing the length of a board, the figure on the rule, that is even with the edge of the board and in line with the number at the end of the rule corresponding to the board's length, shows the board feet in that board. This applies to lumber one inch thick. If the lumber is two inches thick this figure must be multiplied by two. Fig. 75 shows a board which is one inch thick and fourteen feet long. The figure on the rule at the edge of the board and in line with 14 is 7. Therefore, the board contains 7 board feet of lumber.

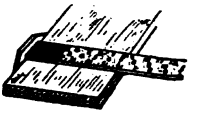


Fig. 75.

65. Use of Sloyd Knife.—The sloyd knife is a good general purpose tool and is valuable for scoring lines. Points are also marked with the sloyd knife. To mark points on a board, a rule is so placed that its graduations touch the surface of the board. With the back of the knife blade against the edge of the rule, fine cuts are made with the knife point. To score lines across stock, the knife point is set at the desired place, and the try-square blade is moved along the work until it touches the knife blade. Then the line is scored. To be straight, a line must be made with the knife held against the blade of the try-square at the same angle for the entire length of the cut. The mark should be fine and clean cut. See Fig. 76.

Fig. 76.

66. Use of the Scratch-Awl.—The scratch-awl may be used for scoring lines and is often called a marking awl. It has a round sharp point and is desirable for scribing heavy materials where a pencil line would not show readily. See Fig. 77.

Fig. 77.

67. Use of the Hammer.—Most hammers are two tools combined, one for striking and the other for different purposes, depending upon the kind of hammer. For general use in woodwork, a claw hammer of medium size and weight is best. In driving nails, except very small ones, the hammer is held near the end of the handle and swung freely in such a manner that the head strikes the nail squarely. See Fig. 78. Light blows are used in starting a nail. If it does not

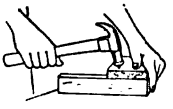


Fig. 78.

start in the right direction, it should be pulled and started again. In pulling a nail, a scrap block of wood placed under the head of the hammer prevents injury to the work. See Fig. 79. For a long nail, thicker blocks of wood should be used as the nail comes out. This prevents marring the work and bending the nail. The face of the hammer should be kept free from grease and glue.

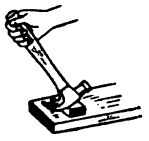


Fig. 79.

68. The Use of the Hatchet.—The hatchet, besides having a head for driving nails, has a cutting edge and a notch for pulling nails. A special type is used for shingling and as a heavy hammer. See Fig. 80. The hatchet is also used for hewing light work. In hewing away stock with a hatchet, a number of cuts are made into the grain, as shown in Fig. 81. By hewing down along the line, surplus stock is removed. In careful work (which should seldom be done with a hatchet) waste stock should not be hewed quite to the line. A small amount of material is left for removal with a plane.

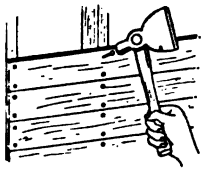


Fig. 80.

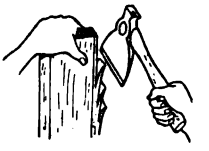


Fig. 81.

69. Use of Mallet.—Mallets are used in driving chisels, gouges, wooden pins, and any tools or work that should not be bruised. They are made in different sizes and shapes, and from different materials, for various uses. The chisel is often injured by using a hammer to drive it instead of a mallet. A mallet is the only tool which should be used to drive wood handled tools. See Fig. 51. In using pounding tools, follow the general rule, that wood should strike wood or softer materials and that metal should strike metal.

70. Setting Nails.—In careful work, where nailing is required, the nail should not be driven entirely in with the hammer, for the last blow is liable to bruise the wood. Instead, the nail should be driven in and slightly below the surface with the aid of a nail set. The nail set is provided with a concave point to prevent slipping. To keep it in place, it is held firmly in the left hand with the little finger resting on the wood against the point of the nail set. See Fig. 82.

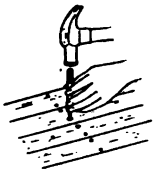


Fig. 82.

71. Filing Wood.—Filing wood should be done only where cutting tools will not serve. An open-cut file instead of a rasp should be used to secure the best work. The curved face of a half-round file permits smoothing the inside edges of curved work. Pressure should be applied on the file only when it is being pushed across the work. If it is allowed to drag when pulled back, the surface is likely to be rounding. The file should not be allowed to rock on the work, but a long even forward stroke should be used. See Fig. 83.

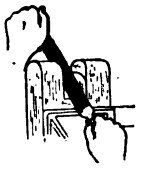


Fig. 83.

72. Use of Pliers.—Pliers are of many sizes, shapes and kinds. In bending, twisting, cutting, holding or shaping metal, pliers, cutters and nippers are used. Pliers are almost indispensible general purpose tools for the average shop. See Fig. 84.

Fig. 84.

73. Grinding Edge Tools.—A grindstone or emery wheel is used for grinding chisels and plane blades. Water is used on the grindstone while grinding to wash away the particles of steel and stone and to prevent friction from heating the edge and drawing its temper. The emery wheel is used without water or oil. The surface of a grinding stone must be kept smooth and straight in order that edged tools may be ground squarely. It should run true and revolve toward the tool. In grinding, a blade is held firmly and at a constant angle to give it a true, straight bevel. For planes and chisels, an angle of from 20 to 30 degrees is sufficient. As the grinding proceeds, the tool is moved from left to right across the face of the grinding wheel. When the bevel has been completed or when the ground surface has reached the cutting edge and all of the nicks have been ground out, the blade is sharpened or finished on the oil-stone. See Fig. 85.

Fig. 85.

During the whetting process, the face of the stone must be clean and plenty of oil used. The blade is held firmly with the right hand and the fingers of the left hand are placed on top of the blade just above the cutting edge. See Fig. 86. The whetting is done the entire

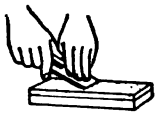


Fig. 86.

length of the stone with a backward and forward or circular motion, keeping the angle between the blade and stone the same and just high enough to keep the heel of the bevel off the stone. When a fine wire edge appears, the blade is turned over, laid flat upon the stone and drawn across the stone to remove the wire edge. Finally, it is finished with a few strokes on a strop. To test for sharpness, the edge is held toward the light. If the cutting edge does not appear as a white line, the tool should be sharp.

If there is no grindstone or emery wheel in the shop, the grinding may be done on a coarse carborundum stone, but it is not as satisfactory.

74. Sharpening Gouges.—An outside bevel gouge is ground in the same manner as a chisel and the wire edge is removed from the inside by means of a slip stone. A slip stone or special emery wheel is used on an inside bevel gouge for both grinding and whetting. See Fig. 87.

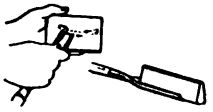


Fig. 87.

75. Sharpening the Draw Knife.—The draw knife is like a wide-bladed chisel and is sharpened in the same manner as a chisel.

76. Sharpening a Knife.—A knife is similar to a chisel but with the cutting edge on the side instead of the end of the blade. The knife has a bevel on both sides, each of which must be ground. In other respects it is sharpened in the same manner as a chisel. It is necessary to keep the original bevel and to see that both sides are alike. See Fig. 88.

Fig. 88.

77. Sharpening a Hatchet.—A hatchet has its cutting edge on the end of the blade, but usually has a bevel on both sides of the blade like a knife. It is sharpened like a chisel, except that it must be ground on both bevels. See Fig. 89.

Fig. 89.

The blade of a broad hatchet has only one bevel and is sharpened in the same manner as a chisel.

78. **Sharpening Screwdriver Bits.**—Screwdriver bits get broken and must be reground. They must not be sharp, but should have a long bevel with side faces nearly parallel. They need only to be ground and this should be done on the side of a grindstone. See Fig. 90. Grinding a screwdriver bit on the face of the stone, unless carefully done, would injure the grinding face.

Fig. 90.

79. **Sharpening a Gage Spur.**—To sharpen a gage spur, a slip stone or very fine file is used. It is sharpened to a flat sharp knife point. One sharp corner is rounded and faced in the direction the gage is to be moved. See Fig. 91.

Fig. 91.

80. **Sharpening Divider Points.**—A divider point should be sharpened to a needle point on the whet-stone or, if very blunt, with a file. A backward stroke is used and the point is revolved on the stone during each stroke. See Fig. 92.

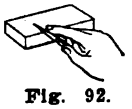


Fig. 92.

81. **Saw Filing.**—Saw filing is difficult work and should be attempted only after careful instruction in the process and observation of the actual work. At first, students should not attempt to sharpen the regular saws, but an old saw should be put aside for practice. The saw is fastened in a saw vise with the teeth up. See Fig. 93. Top jointing is done by running a flat file or saw-jointer along the top of the teeth until the file in passing touches the top of each tooth. The saw is set with a saw-set. This operation consists of bending the teeth so the saw kerf will be wider than the blade. Alternate teeth are bent the same way for the same distance. The teeth, numbers 1, 3, 5, etc., are set from one side, then the saw is reversed and the others set. Filing is done with a three-cornered file. The file should be held at each end and pressure applied on the forward stroke, using a long even stroke. The teeth bent away from the worker are filed and then the saw is reversed and the process repeated. In filing a cross-cut saw, the file is held pointing upward and forward. In filing a rip-saw, the filing is done perpendicularly across the blade, the back of each tooth being filed. After filing, the sides of the teeth are rubbed lightly with a slip-stone to remove the wire edge.

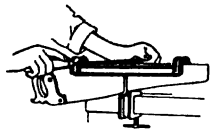


Fig. 93.

82. **Sharpening a Scraper.**—Each edge is drawfiled to make it straight and square by putting the scraper in a vise and moving a smooth file, held at right angles to the edge of the scraper, from end to end of the edge. Next, the sides and edges of the scraper are rubbed on the oil-stone to remove roughness and make two sharp arrisses. See Fig. 94. Then, it is placed in the vise again and a burnisher used to turn the sharp arrises over the side of the scraper.

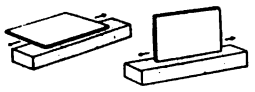


Fig. 94.

83. **Sharpening Auger Bits.**—An auger bit file is used to sharpen a bit. The nibs on the inside are sharpened with the flat side of the file to preserve the original diameter of the bit. The cutting lip should be sharpened on the side near the spur with the edge of the bit file. The original angle of the lip must not be destroyed. The upper side of the lips and the outside of the nibs should not be touched with a file. See Fig. 95.

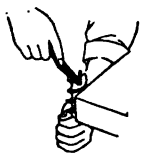


Fig. 95.

FURNITURE AND CABINET MAKING

84. Operations applying directly to furniture and cabinet making, and not presented under carpentry, are given here.

In woodwork, the fastening together of two or more parts is called "joinery". Different types of construction and different requirements involve the use of many kinds of joints. A description of common joints, with their trade uses, is given in the following paragraphs. A number of these joints apply to carpentry construction.

85. **A Fished Joint** may be used wherever it is necessary to increase the length of a beam. The ends of two pieces are placed together and fastened by bolting or nailing a short wooden or metal plate to either one or both faces of the timbers. See Fig. 96.

Fig. 96.

86. **A Toe-nailed Joint.**—A toe-nailed joint is used in rough construction, and general repair work. It is used in buildings to fasten the studding to the sills. One piece of material is made to butt, or fit, against another, and it is fastened in this position by nails driven at an angle as shown in Fig. 97.

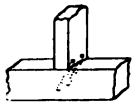


Fig. 97.

87.—**A Doweled Butt Joint** (Fig. 98) can be made where it is not desirable to use screws or nails. It is used in cabinet work instead of a mortise and tenon joint where the strain is largely one of compression. This joint consists of dowels forced into holes, bored part way through each piece. Usually the joint is glued besides being doweled. If the face of the piece is not to be exposed, the dowels may go through the outside face.

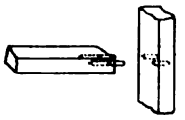


Fig. 98.

88. **A Draw-bolt Joint** is used in the construction of wooden machine frames and various types of wooden benches. It is a strong joint and can be tightened, if the wood shrinks. It is made by putting a bolt through a butt joint in the manner shown in Fig. 99.

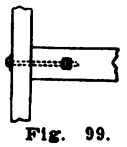


Fig. 99.

89. **A Plain Butt Joint** is used in cabinet, case, and box construction. It is easily made, consisting of an end and a face or edge of pieces joined with glue, nails or screws. See Fig. 100.

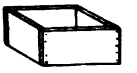


Fig. 100.

90. **A Hopper Joint** is employed in bins and hoppers on machines. It is similar to the plain butt joint except that the ends are cut at an angle to the edges and the edges at an angle to the faces. See ends **a-b** and edges **c-d** in Fig. 101. When fastened together, joints as shown in Fig. 101 are made.

Fig. 101.

91. **A Cross-lap Joint** (Fig. 102) is used in almost all construction work where pieces of material running in different directions must cross. The joint is made by cutting away one-half the thickness from each piece so that both occupy the thickness of one piece.

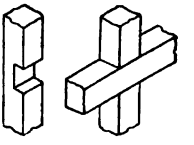


Fig. 102.

92. **A Middle-lap Joint** is often used in cabinet work and in carpentry to join stretchers to rails. It is T-shaped and made similar to the cross-lap, except on one piece the cut is made at the end instead of at the center. See Fig. 103.

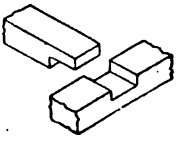


Fig. 103.

93. The End-lap Joint is common in frame construction where the ends of two pieces are put together at right angles to each other. It is sometimes used in making door frames and window screens. Half the material is removed from the end of each piece, and the pieces fastened together in any manner desired. See Fig. 104.

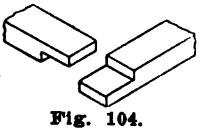


Fig. 104.

94. A Notched Joint is used in fastening joists to wall plates to hold them in place and to lower the surface of the upper piece. Only one piece is notched. See Fig. 105.

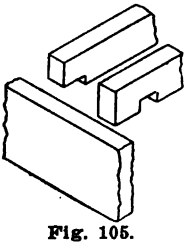


Fig. 105.

95. A Rabbet Joint is adapted to box construction or similar work. A rabbet in the edge or end of one board receives the end or edge of another piece. The joint is secured with nails, screws, dowels, or glue. See Fig. 106.

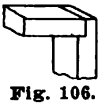


Fig. 106.

96. A Dado Joint is found in drawer, step, and other similar construction. A dado (groove across the grain) is cut into one piece to receive the edge or end of another piece. See Fig. 107.

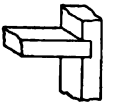


Fig. 107.

97. A Dado and Rabbet Joint is common in case, box, and drawer construction. A rabbet is cut in one piece and a dado in the other, so that the two pieces fit tightly. This makes a strong glued joint. See Fig. 108.

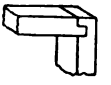


Fig. 108.

98. A Gain Joint is used in partitions in trays and boxes, for inserting braces in cabinet work, and in shelf construction. It differs from a dado joint by not running entirely across the piece grooved. A notch is cut in one piece and a partial dado across the other. It conceals the end of the piece let into the other and also has supporting strength against downward pressure. It does not depend entirely upon nails or screws for its support. See Fig. 109.

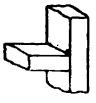


Fig. 109.

99. A Stub Mortise and Tenon.—Where the edges or faces of two pieces are flush, they may be held in place by a stub mortise and tenon joint. This joint is used in rough work such as framing construction and sometimes in cabinet construction where the main object is to prevent lateral motion of an upright piece. See Fig. 110.

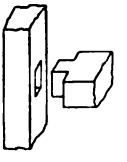


Fig. 110.

100. A Blind Mortise and Tenon is the best known and most used mortise and tenon joint. It is used, to a large extent, in furniture construction. The tenon extends only partially through the mortised piece, giving the neat appearance of a plain butt joint, and more strength. See Fig. 111.

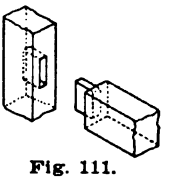


Fig. 111.

101. A Through Mortise and Tenon is used in the construction of sashes, etc., and in some furniture and cabinet work. It is similar to a blind mortise and tenon except that the mortise extends through the piece. Where the mortise is not exposed, or in rough work, this does not matter. In furniture and cabinet making, when an exposed through mortise and tenon joint is used, the tenon is usually extended beyond the mortise for decorative effect. See Fig. 112.

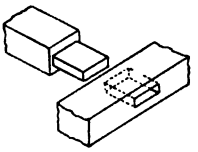


Fig. 112.

102. A Pinned Mortise and Tenon is used for strength in heavy framing and construction work. It is made by fastening a mortise and tenon by means of a pin inserted in a hole bored laterally through the mortise and tenon. See Fig. 113.

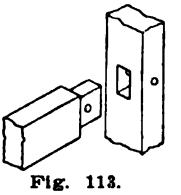


Fig. 113.

103. A Keyed Mortise and Tenon is used for ornamental purposes and in knock down work as in certain pieces of furniture. It is often used in bench construction. See Fig. 114. It differs from the through mortise and tenon by having the tenon extended through far enough to be mortised and receive a wedge. Also the shoulders of the tenon are cut only on two sides.

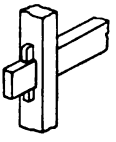


Fig. 114.

104. A Slip Mortise and Tenon, or slip joint, is used for corner joints of frames, where the stress is not great. The multiple slip joint used in box corners is made by machine. The tenon is shouldered only on two sides, and the mortise is made at the end of the piece, with one side open. See Fig. 115.

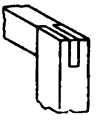


Fig. 115.

105. A Through Multiple Dovetail is used for strong box corners and often for fine ornamental boxes. It consists of a series of dovetails with the tenons exposed on each edge. See Fig. 116.

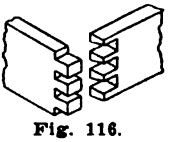


Fig. 116.

106. The Lap Dovetail is used where one side of the joint is hidden, as in joining the side of a drawer to the front. The tenons or dove tails on one piece do not extend through the other piece. See Fig. 117.

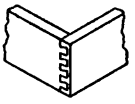


Fig. 117.

107. A Miter Joint is used in picture frames, mitered corner boxes, pedestals, interior wood trim and similar work. Pieces are properly beveled, placed together and fastened with glue, nails, screws or dowels. See Fig. 118.

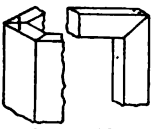


Fig. 118.

108. A Brace Joint is used for supporting and bracing beams. The ends of a piece are cut to the proper angle and the piece nailed in place. See Fig. 119.

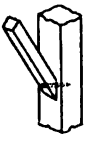


Fig. 119.

109. A Housed Brace Joint is used where greater strength is required than that obtained by the nailed brace joint. The ends of the brace are given a double miter and housed in the work which they support. See Fig. 120.

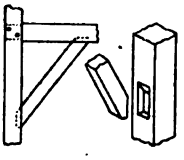


Fig. 120.

110. A Glue Joint, often called a plain joint, is used in making table tops, and other work requiring more than one board. It consists of gluing boards together edge to edge. See Fig. 121.

Fig. 121.

111. A Rabbeted Joint is used largely in siding and rough flooring. A rabbet is cut out of one side of each piece of wood and the pieces are fitted so as to overlap on the edge. See **a**, Fig. 122. When boards are rabbeted on adjoining edges and the space filled with a strip, or fillet, it is called a **fillistered joint.** See **b**, Fig. 122.

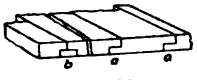


Fig. 122.

112. A Matched Joint, often called a tongue and groove joint, is used principally in flooring. It consists of a grove near the centre of the edge of one board and a tongue on the edge of the other which fits the groove so that the boards are flush on the upper surfaces when placed together. See Fig. 123. A

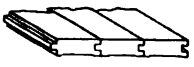


Fig. 123.

Fig. 124.

matched joint with a bead on one edge for decorative effect is called a **beaded joint.** It is shown in Fig. 124.

113. **A Spline Joint** is used in heavy table top construction and heavy flooring. Grooves in the edges of the boards are joined by inserting a narrow strip called a "spline." The grooves are cut so that the boards are flush on their upper faces when joined. See Fig. 125.

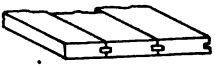


Fig. 125.

114. **A Doweled Joint.**—A doweled joint is stronger than a plain glue joint and may be used in most glue joints where the boards are thick enough to accommodate the dowels. Table tops, drawing boards, etc., are usually joined by a doweled joint. The dowels are inserted in holes bored in the edges. Glue is applied before the boards are finally joined. When joined, the top surface of the boards are left even. See Fig. 126.

Fig. 126.

115. **Gluing and Clamping Work.**—The kinds and nature of glues are discussed in Arts. 277 to 280 in Sec. 2. Their use will be taken up here. Both cold and hot glues are used in gluing up stock and in fastening finished parts of wood structures together. Hot glue which is prepared by heating water-soaked dry glue in a glue pot or double boiler, is stronger than commercial cold glue. When hot glue is ready for use, it should be thin enough to run from the brush in a thin stream. The wood should be warmed when hot glue is applied to prevent it from chilling. The strongest glue joints are made by gluing the edges of boards together. End grain must always be sized before final gluing takes place.

There are two types of glued joints—rubbed and squeezed. The rubbed joint is usually edge to edge gluing. The boards should be planed so that they make a close fitting joint when temporarily placed in position. Glue is placed on the edges and the edges are rubbed slowly back and forth until the glue is spread evenly and thinly and the excess glue expelled. As soon as the rubbing becomes difficult, due to the drying of the glue, the boards should be stopped in the desired position and left to dry.

A joint made with the aid of clamps is called a squeezed glue joint. It is better to clamp a joint, to hold the work tightly in place while the glue sets, and to expel surplus glue. Edge joints to be glued and clamped are usually doweled, (Fig. 126), matched, (Fig.

123), or splined, (Fig. 125). A joint to be clamped should have the edges that are joined very slightly concave to counter-act shrinkage of the boards at the ends.

Joints to be glued should be assembled before applying the glue, to see that they fit properly. Before applying glue, the clamps should be set ready to use and blocks to protect the wood should be at hand as well as all other tools used in the process. After hot glue is applied to a joint, it should be clamped quickly to get the parts together before the glue cools. All work should be tested for position and squareness and remedied, if needed, before the glue sets. Surplus glue expelled from the joint may be easily removed after it chills by using a sharp steel scraper or similar edged tool. This is easier than to let the glue set in the grain. A damp cloth may be used immediately to remove the surplus glue.

Much glued work can be clamped together in sections to great advantage. For example, the sides of a chair may be glued up and the final assembly made when both sides are dry and out of the clamps. For small work, where possible, hand screws should be used. See Fig. 54. Cabinet clamps are used (as explained in Art. 51) to clamp large work, such as table tops. In clamping together the frame of a table, it is essential to locate the clamps directly over the part being clamped. Scrap blocks of wood should be used between metal clamp jaws and the object being clamped to prevent marring the surface. Special clamps are used to glue up picture frames and columns. See Fig. 127.

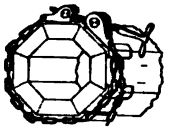


Fig. 127.
Column Clamp.

116. Finishing Wood.—Before assembling work, and again before the final finish is applied, the surface should be put into a good smooth condition. This is one of the most important steps in finishing. A surface should first be planed as smooth as possible to remove mill marks and to make it even. Cross-grain, curled spots, and a torn surface should be smoothed with a scraper. See Fig. 46. After all tool work has been done the surface should be sanded. Sandpapering should be done with the grain, with the sandpaper over a block of wood, which fits the surface. Usually work to be finished with a coating of some kind, should be assembled before the finish is applied.

117. A Stain Finish is obtained by first applying stain to the surface. Later the wood may be filled and polished. Of the three types

of commercial stains, water, spirit and oil, the latter can be used with the best success by beginners. Water stain "roughs up" the wood. Spirit stains penetrate wood deeply and are good for hard wood, but they fade, are expensive, and tend to go on unevenly because they dry quickly. Oil stains should be applied with a brush and wiped evenly and dry with a cloth, as soon as one surface is covered.

The brush should be dipped about one-fourth the length of the bristles into the stain, and then enough stain wiped off to prevent dripping. At the start, the stain should be applied near the end of the surface and brushed with the grain. Low and interior surfaces, edges and ends should be stained before the important or raised surfaces. A stain finish may be followed with a filler and shellac, wax or varnish. See Arts. 224 to 227, Sec. 2.

118. A Fumed Finish is obtained by exposing certain woods to certain chemical fumes for 24 hours or more, depending on the color shade desired. Fuming gives a deep stain finish to the wood. The most successful fumed finish is made on oak by enclosing it in a tight box in which a dish of (28%) ammonia has been placed. See Art. 228, Sec. 2.

119. Fillers are used to fill the pores of the wood and make a smooth ground surface on which to apply shellac, varnish or wax. The liquid filler, which is usually shellac, should be brushed with the grain to fill the wood pores. After it is dry, it may be sanded smooth and a varnish applied. For open grain woods, like chestnut, ash and oak, a paste filler should be used. The filler should be mixed to the consistency of thick cream and applied with a stiff brush. After drying until dull, it is rubbed off, across the grain of the wood, using a cloth or similar material. A day should be allowed for the filler to harden before applying varnish or wax. See Art. 231, Sec. 2.

120. A Shellac Finish.—Shellac makes a good foundation for a varnish finish. Also one thin coat is an excellent base for a wax finish. Using a flat brush, the shellac is applied with the grain of the wood. It may be smoothed when dry with very fine oiled sandpaper or fine steel wool. Thin coats should always be used. See Art 223, Sec. 2.

121. A Wax Finish is made on a stained, filled, and sometimes a thinly coated shellac surface. A thin coat of prepared paste wax is

applied with a cloth, to cover the surface. After drying ten to fifteen minutes, it is rubbed briskly with a dry cloth. After a few hours, another coat of wax is applied in the same manner. This is repeated until the desired degree of finish is obtained. See Art. 230, Sec. 2.

122. **A Varnish Finish** is used where a high polish is desired. It should be applied on dry smooth surfaces in a warm room. The rubbed varnish finish is used to make the best job, but much varnish is applied to interior woodwork without rubbing any of the coatings. After a surface has been stained, filled, shellaced and sanded to a smooth finish, a coat of good grade rubbing varnish may be applied with a varnish brush. It is allowed to dry about forty-eight hours and then rubbed with fine steel wool or curled hair until smooth. Two coats at least should be applied in this manner and an additional coat, likewise, which should be rubbed with powdered pumice stone and linseed oil, the rubbing pad being made of felt. A polished finish can be obtained by rubbing with powdered pumice stone and water. A surface should be rubbed smooth, even and without pits, but not through the varnish. A wet sponge will remove the pumice. See Art. 222, Sec. 2.

123. **Assembling.**—The bringing together and fastening of the parts of a piece of work is called assembling. Parts are fastened with glue,

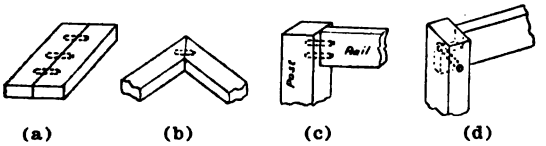


Fig. 128.

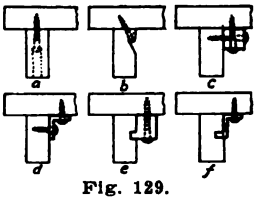


Fig. 129.

screws, brads, dowels and similar wood fastenings. To illustrate: The ends of a plain library table, consisting of two legs and two rails, are glued, and clamped together, and the joints doweled. These end sections are then joined in a similar manner by rails. Fig. 128.

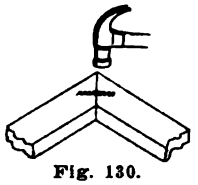


Fig. 130.

Screws are used to fasten the drawer slides to the table and brads are used in the drawer construction.

Angle irons, blocks and screws, or screws alone, should be used to fasten the table top to the rails. See Fig. 129.

Corrugated nails are often used in fastening the corners of window screen frames or in drawer construction to hold the boards used for the bottom together. See Fig. 130.

124. Hardware.—In building and in cabinet work much hardware, such as knobs, locks, pulls and bolts, is used. In attaching hardware, the place in which it is to fit should be carefully located and marked with accurate measurements. Small guide holes for the screws should be drilled, especially in hard woods. Screws should not be driven with a hammer. See Fig. 65.

Fig. 131.

Hinges are usually attached in two ways: (1) On the surface for ornamental and common heavy work. (2) Sunk into the surface for strength, and to hide the hinge. Tee, strap and screen door hinges are put on the surface. Butt, chest and piano hinges are let into the wood. Before attaching hinges, the parts should fit. Door hinges are usually placed just below and just above the top and lower door rails. On boxes, cases and chests, the hinge is set about twice its length from the end. When the hinges are located and their position marked, they should be removed. Then holes are bored or mortises cut and the hinges fastened in place. See Fig. 131.

Locks are classed as surface or mortise types according to their method of attachment. On doors they are placed slightly above the middle, but when used on chests, boxes, trunks and desks they are placed in the center, if only one lock is used. A surface lock is held in place and the key-hole located. The key-hole is cut, and also a place for the selvage and lock box, if necessary. The lock is screwed in place. See Fig. 132. Then the face plate is located and mortised in, if the job requires one.

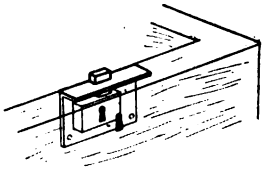


Fig. 132.

Fig. 133.

A mortise lock must have the key-hole and knob bar located and holes bored for them. The location of the mortise is marked and cut for the box and selvage. Then it can be fastened in place. The face or strike plate is fastened, the escutcheon added and the knob attached. See Fig. 133.

PAINTING AND DECORATING

125. Putting on Paint and Enamel.—Paint protects and adds beauty to surfaces. It is used on both interior and exterior work for painting wood, metal, stone and brick, also in finishing vehicles, in sign work, etc. Although the kinds of paints and the number of coats applied vary with the job, the method of application for all paints is practically the same. The following describes the method of application of paint on exterior wood surfaces.

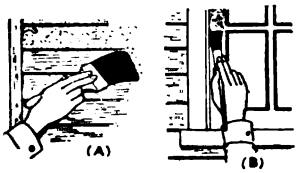


Fig. 134.

The first coat is called the **priming coat.** It unites all other coats to the surface and should be applied to a dry surface with a long bristled brush. See Fig. 134. The paint should be brushed well to completely cover the surface. For a good priming coat, white lead or lead and ochre, finely ground in linseed oil and thinned with raw linseed oil, should be used. If three coats are to be used, a **second coat** should be applied after the priming coat is dry and all holes, cracks and wide checks have been puttied. If the second coat is the last coat, it should be thick, otherwise the second coat should be thin. After the second coat has dried hard, the **third coat** can be applied. Before starting the last coat, and to assist in securing a smooth finish, the second coat may be lightly sandpapered to remove all streaks and spots of dust and dirt. The paint for this coat should be rather thick, evenly applied, and brushed out smoothly.

Enameling of wood is often done on interior wood work. For new work, the wood should be clean and the work free from dust. For a white enamel finish, the work should first be **primed** with white lead and linseed oil and allowed to dry for at least a week. Then, the second coat of flat white and zinc white can be applied. One or two more coats can be applied, allowed to dry, and sanded to a smooth surface before the next-to-last coat containing some varnish is put on. The finish coat to be applied over the smooth, even, white surface should be of good quality damar varnish. The last two coats should be applied with a camel's hair brush.

126. Color Mixing.—Mixing paints to match certain samples requires a knowledge of color and materials, good judgment and careful attention. Tints mixed in oil are much easier to handle than those mixed in water colors, because the water color tints must dry to show the finish color, while it is always apparent while mixing oil color tints. In

oil paints, the base which contains the important prevailing tint should be mixed with linseed oil by stirring until it is well mixed to the consistency of cream. The tinting pigments are thinned with linseed oil and turpentine, strained and added gradually to the base and mixed thoroughly. All tints required to obtain a desired color should be added in this manner. The only remedy for a mixture of too much coloring pigment is to add more base to dilute the color.

127. Graining and Stenciling.—Graining is a method of applying graining colors to obtain a finish resembling natural wood. With the introduction of various hard woods and particularly oak into interior building construction, the graining process became less important. It is used, however, to a certain extent in finishing bed-rooms in maple and mahogany and for graining sheet metal and composition board used in furniture and wall construction. Metal is being used a great deal in the place of wood and by graining is made to closely resemble wood.

To prepare a surface for graining, it should first be given a priming coat of white lead and oil mixed with a pigment to give the proper ground tint. A flat or oval brush is used to put on the ground coats which should be evenly applied. To be familiar with all grains of wood in their many variations, the grainer should study the structure, growth and the beauty of grains from the actual woods. To become skilled in the art of graining, it is necessary that a great deal of time be spent in practice, copying and study before the real job is attempted. After the prepared graining color is mixed with a warm thinning oil, it should be applied and "rubbed in" evenly upon the prime or ground coat with a good sized brush. The panels or lower surfaces of work should be covered before the raised parts. The surface is then ready for the grainer to wipe out and comb the panels to imitate the grain desired. The wiping out is done with a rag over the thumb by wiping the ground to be grained as the work proceeds and following over this ground with a comb.

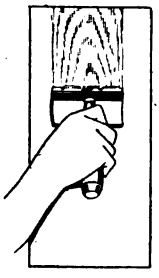


Fig. 135.

Rubber graining rollers can be used but the effect produced by them is somewhat mechanical. See Fig. 135. If a checker roller is used, it is necessary to use a camel's hair lettering brush to pencil in the veins.

Stenciling is a method of decorating walls, fabrics, boxes, etc.,

with conventional and repeated designs. The stencil is prepared by laying out the desired design upon stencil material which may be thin brass for continuous use, or special prepared paper. The material is then placed on a hard, smooth, level surface, such as plate glass, and the design cut out with a good, sharp stencil knife.

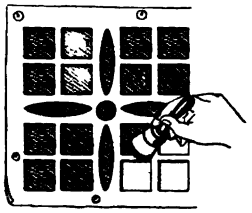


Fig. 136.

In stenciling a large perpendicular surface, a chalk line should be run as a guide for placing the stencil horizontally and a plumb bob used to get the perpendicular direction. The stencil is then held with one hand or fastened with thumb tacks and the color pecked on with a stencil brush, lightly filled with the proper color.

Brushing on the paint would cause it to run under the edges of the stencil and make a blur. See Fig. 136.

128. Calcimining and Frescoing.—Painting a plastered wall with water colors is called calcimining. The artistic or decorative painting of walls is known as fresco painting, and may be done in either oil or water colors. Before calcimining, the walls may need to be sized with a specially prepared varnish surfacer. The surfacer, if used, should be allowed to dry from 12 to 24 hours before applying the calcimine. It should be applied on large surfaces with a 6″ to 8″ calcimine brush and laid on so that it covers every portion of the work. After the calcimine is mixed and the walls are in a fit condition, the calcimine can be applied. The color is usually put on the short way of the surface and then cross-brushed. Small, flat and round brushes are used by the decorator for lining off work, reaching into corners, and covering small surfaces.

Fresco Painting in oil is the most satisfactory way for permanency and looks, although water colors are used to a large extent. Walls covered with oil fresco paint can be washed. To make a good finish with oil fresco paint, the walls must be prepared by covering the surface with a coat of glue and one of gloss paint or two or three coats of oil paint, each method followed by a coat of flat paint. The fresco color is then applied and the decoration put on. The cheaper decorating is done by the use of stencils. This decoration is easily accomplished by the use of the commercial decorative schemes. The design is first put on a sheet of manila paper, then perforated with a tracing wheel. It is then transferred to the surface to be decorated by pounding over the design with a piece of cheese cloth filled with a black powder. The stencil is removed and then the design can be filled in with a brush and color to suit.

PATTERN-MAKING

129. The making of metal castings includes three distinct processes. First, a **pattern** is made of wood, or some other easily shaped material, almost like the desired casting. Second, from this pattern a mold is made, and third, metal is melted and poured into the mold.

A pattern is used in making the mold. Although a wood pattern is made by processes similar to other woodworking projects, it must be made more accurately and allowances made for draft, shrinkage of the metal in cooling and for waste in machining the casting. Patterns are of many types, as those not requiring cores, those with cores, and patterns made in one or many sections. Making patterns is the task of the **pattern-makers,** making molds the work of **molders,** and melting and pouring metals the job of **foundry workers.**

130. Layout of Work.—The accuracy, size and shape of patterns constructed to correct dimensions depends first upon the location and making of lines. The knife with a good sharp point should be used to cut lines across the grain and the gage should be used for lining with the grain. For circles and arcs, the dividers with a chisel cutting edge on one leg can be used. The dividers should also be used in laying out and transferring angles.

Lines in positions difficult for laying out with the knife and gage can be laid out with a sharp pointed pencil. A chalk line is often used for lining on large patterns. In pattern-making, in addition to the regular carpenter's tools for laying out work, the **shrink rule,** which is constructed to make due allowance in the pattern for shrinkage of metal, is a necessity. After the pattern-maker has consulted the working drawing or blueprint and determined upon the method of construction, it is then necessary to work out the foundation part of the pattern upon which is made the first layout.

White pine, because of its particular suitability, makes the best pattern wood. Although small patterns are built from one piece of wood, it is much better to construct the pattern of several pieces and thus eliminate warping to a large degree and increase the strength. Fig. 137.

Fig. 137.

Thin patterns should be built up of three layers, the grain in each running in different directions, and each layer put together in sections. Other patterns are built up in layers and segments. See Fig. 138. To obtain strength and durability in the pattern, it is usually made up of sections. The pattern for such castings

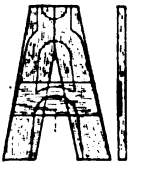


Fig. 138.

as a shafting hanger or the end leg section of a lathe is first laid out on a structure representing the largest part.

The shrink rule should be used because it is always necessary to make allowances for the shrinkage of metal in the casting. Also waste for machining, and draft in laying out the pattern must be provided for. After the pattern is roughly cut out, projecting lugs, webs, and other parts which are to extend out from the surface, should be glued on in pieces. The pattern is then cut to size. Most patterns are built up and laid out as the construction progresses. For pulleys, the arms are laid out first and roughly cut to size, after which the flanges and rims are glued up in sections and turned to size on a lathe.

131. Making the Pattern.—Wood is used more extensively for patterns than metal. The lumber used in patterns should be quarter-sawed to prevent warpage and air seasoned for at least two years. It should be straight, even grained and capable of being worked easily.

Fig. 139.

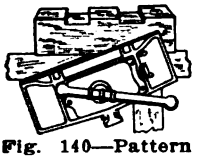


Fig. 140—Pattern maker's vice.

All pieces of wood entering a pattern should be accurately trued to size. They are glued up in the same manner as cabinet work and reduced to size and form with the same tools. However, on account of the draft required to remove the pattern from the mold, it is necessary to taper work slightly.

In making a pattern as much work as possible should be done on a power machine. The band saw should be used to cut out all flat surface patterns. See Fig. 141. The turned or round parts should be

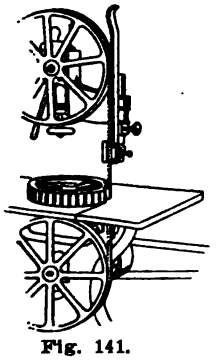
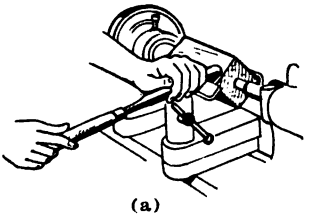
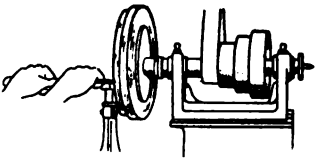


Fig. 141.



(a)



(b)

Fig. 142.

turned out on a lathe. See Fig. 139 and a in Fig. 142. The shaping methods all follow the building up and laying out of the pattern. A boring machine fitted with Foerstner bits can be used to rough out many parts of patterns, such as cutting between the arms or spokes in a pulley. Much of the work of wheels and pulleys are built-up on a lathe chuck

to which has been fastened a wood disc or armed surface. See **b** in Fig. 142. Calipers and rules are used for testing, but for duplicate work a template can be used to advantage.

132. Finishing the Pattern.—In the construction of some patterns, it is advisable to make the parts individually and assemble them when the parts are finished. The majority of the patterns, however, are put together as the job progresses. The pattern should be shaped and sized accurately with cutting tools. Sandpaper is used to smooth the surface of patterns but not to do work that can be done with tools. Pattern sanding machines are used to make round parts on castings and thus increase their strength and add to the appearance of the finished work. Sharp, internal corners are finished by filling in all angles with leather, wax or wood fillets. A wood fillet is usually glued in place in the form of a block of wood with an edge chamfered, after which it is cut to the proper curve. Wax is used as a fillet and is best applied by covering the surface with glue and pressing it in place with a rod having a sphere at the end. See Fig. 144.

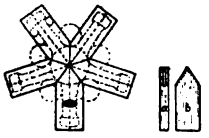


Fig. 143.

Fig. 144.

All holes and other defects in the wood should be filled with beeswax after a coat of orange shellac or varnish has been applied. The shellac is applied after the pattern is fitted with fillets except where wax is used which is applied after the first coat of shellac. Each coat of shellac before the last should be sandpapered smoothly. The core prints are always covered with a different color shellac, usually black, to show the location of the cores in the mold.

MOLDING AND CORE MAKING

133. Making the Mold.—To make a mold of a pattern, the molding board is placed on the foundry floor in a level position. The half of

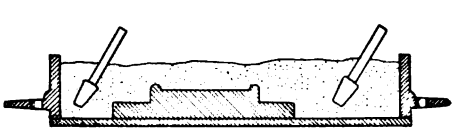


Fig. 145—Ramming sand around pattern and into corners.

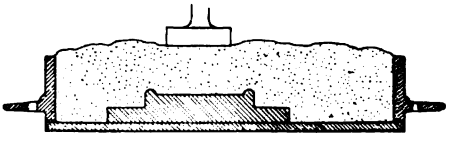


Fig. 146—Ramming in sufficient sand to finish filling flask.

a split pattern without the pins is placed face down upon the board, the lower half of the flask is placed upside down over the half

pattern and the pattern covered with about one inch of sifted molding sand. The half flask is then filled with the sand and rammed down solid. See Fig. 145. After it is leveled and the bottom board clamped in place, the whole is turned over and the molding board removed. The surface should then be sleeked with a trowel, even with the pattern, and covered with parting sand. The other half of the pattern, the sprue pin and the top of the flask are then put in place. After the flask is filled with sand and rammed even with the upper edge of the flask and the pin pulled out, (Fig. 147), the upper part of the flask is carefully removed by lifting it vertically.

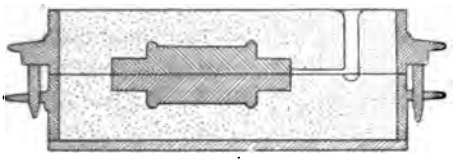


Fig. 147.

It is now necessary to remove the halves of the pattern by inserting the lifting screw or draw spike and rapping gently on all sides to loosen the pattern, after which it can be lifted out. After taking the pattern out, it is necessary to provide a gate for the melted metal by cutting a channel in the sand of the bottom of the flask from the cavity to the spot marked by the sprue pin. The core (if any is required) can then be set and the two parts of the flask put together as determined by the guide pins, thus making it ready for pouring.

134. Operating the Cupola.—The cupola is a furnace in which the iron is melted for the castings.

After a cupola has been cleaned, repaired and properly daubed with a mixture of sand and clay, the bottom covered with sand and the breast tap hole and spout formed, it is ready to be filled or charged with fuel, iron and flux. The fire is built of shavings, oily waste, straw, wood or similar material and coke or coal added in layers as the fire burns.

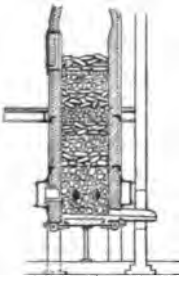


Fig. 148.

Iron is then added and a flux of limestone, chalk, clam shells, etc., may be used to absorb the dirt and float it out through the slag hole. A blast of hot air is then forced into the cupola to melt the iron rapidly. This heated air causes the fuel to burn fiercely and raises the temperature above 2,200° F. Gages on the cupola are used to measure the pressure of the blast. Slagging, which consists in removing the floating dirt and flux from the iron, should be done at least every two hours. When the metal is melted to a freely flowing liquid, it is drawn from the cupola by tapping. See Fig. 148.

135. Pouring.—After the iron is heated to the proper temperature, it changes into a molten mass and is then ready for pouring into the molds. The cupola is tapped by punching the clay away from the tapping hole with a long pointed bar. This allows the melted iron to run out. After the first iron which is impure is drawn off, a large ladle is filled. A ball of clay on the blunt end of a stopping rod is used to close the cupola and stop the flow of metal. From the large container smaller ladles may be filled. A small ladle, with one handle, to be managed by one man, is very convenient for small molds, but a large one to be carried and handled by two men is capable of filling large molds or several small ones. When the ladle is directly over the mold, it is tilted enough to allow the metal to run from the ladle into the pin hole until the mold is full. See Fig. 149.

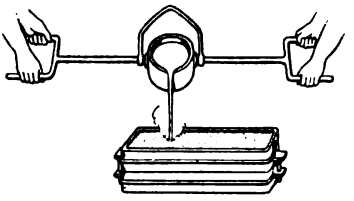


Fig. 149.

After the iron in the molds has cooled, the flasks are removed and the castings taken out of the sand.

136. Making and Baking Cores.—Cores are used to make holes through castings by locating them properly in the sand mold.

The attachment necessary to hold a separate core in place is called a **core-print.** Molds having no core-print to hold the core in place require the use of wire rods and special core anchors to hold the cores in place. Dry sand cores are those usually made separate from the mold. Green sand cores are usually made in connection with the mold. It is necessary to have a core-box, in which to make dry-sand cores. One is illustrated in Fig. 150. Cores that are symmetrical can be made in a half box and two sections pasted together. Core boxes require as much care in the making as the pattern, and must be planned in connection with the pattern.

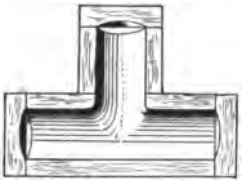


Fig. 150.

Cores are made by ramming the core sand mixture into the core box with a rod small enough to pack it evenly and solidly. To strengthen small cores, a rod or wire is placed in them while being formed. Cores are vented as near the center as possible to allow the gas to escape as the casting is poured. Venting in small cores can be done by making a small hole, while in large cores cinders can be used. Binders of flour, resin and oil should be used in core sand mixture to give strength to the core.

After the core is formed, it can be carefully placed on a smooth, straight plate for drying. Cores should be blackened with a mixture of drying blackening and glue water, or diluted molasses.

When a plate has been filled with cores, it should be put into a drying oven as soon as possible. The oven is heated to a high temperature with a blast of dry, hot air. The cores should be left in the oven until they are thoroughly baked.

MACHINE SHOP PRACTICE

137. Chipping.—Although much work in metal formerly done with the chisel, hammer, and file, is now machined, it is still necessary to employ these tools on some jobs. Wrought iron may be chipped, but chipping is done principally on cast iron. A chisel for chipping should be ground at an angle of about 70° to the horizontal.

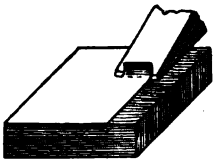


Fig. 151.

A cross, ball, or straight-pein hammer, weighing about 1-lb., is used to drive the chisel. After the surface of the work has been chalked out and the outline marked with a prick punch, the piece is fastened in a machinist's vise. A piece of brass or cardboard should be placed between the work and the vise jaws for protection. The surface should be chipped toward the stationary jaw of the vise and the cutting edge of the chisel watched carefully. See Fig. 151. The chisel should be held loosely in the left hand and driven by light blows. A cape chisel is used to chip grooves in the surface of cast iron.

138. Filing and Scraping.—A file should be selected with regard to the type of work to be done, and the metal used. A coarse file is ordinarily used to get a true surface, after which a smooth-file is used to make a fine surface. The work to be filed should be fastened securely in the vise at a height slightly below the elbow. The file should be held in the right hand with the left hand resting on the end of the file. See Fig. 152. A full stroke at an angle should be used with the file bearing evenly on the surface of the work. Where the work is narrow, the filing should be straight across. The pressure is relieved on the return stroke.

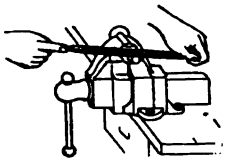


Fig. 152.

Draw Filing is a method of finishing work by drawing the file over the work at right angle to its length. To produce a true surface, it is necessary to change the position of the file frequently. Very accurate work of a smooth, fine finish can be done by draw filing.

Scraping is employed in cutting filed surfaces down to a more accurate finish and in fitting two surfaces together which are to bear upon each other. In scraping a pair of surfaces, a surface plate should be used in order to test the surfaces being trued. They can be tested by using a slight coating of red lead or lamp black and rubbing the plates together. A straight scraper is pushed away and a curved scraper is pulled toward the workman.

139. Testing.—Accurate testing is a very important operation in the machine shop. A piece of work may be well finished, but, if it is not accurate, it will be worthless.

Many instruments are used in testing, chief of which are: standard gages, scales, plug gages, vernier calipers, micrometers, squares, straight edges and spring calipers. The last three are the most common, although the micrometer caliper is, perhaps, the one most used in high grade machine shop work, because it determines with a high degree of accuracy.

140. The Micrometer Caliper is used for both inside and outside measurements. It has an adjustment range of one inch and can be adjusted to the one ten-thousandth of an inch. See Fig. 153.

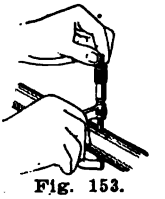


Fig. 153.

141. The Square is used to test right angles and short surfaces. The back or exterior edge should be held against a finished face. See Fig. 154.

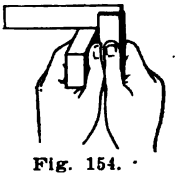


Fig. 154.

142. The Straight Edge is used largely for testing the accuracy of long surfaces. See Fig. 155. Wind in a plate may be determined by placing straight edges at opposite edges of a surface and sighting across them.

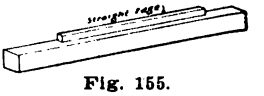


Fig. 155.

143. Spring Calipers are made for measuring inside and outside surfaces. See Figs. 156 and 157. They are set from a special gage or machinist's scale. In roughing work to size, they are used to advantage. When turning stepped cones, one set of calipers can be used for each measurement.

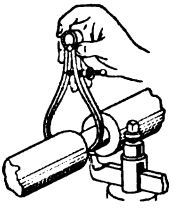


Fig. 156.

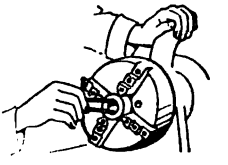


Fig. 157.

144. Hack Sawing.—A hand or power hack saw is used to cut up stock for turning and other machine shop purposes.

For cutting with a hand hack saw, the stock should be measured with a scale and marked off with a prick punch. It is then fastened securely in a vise. The saw should be grasped with the right hand, the upper part of the frame supported by the left hand, and pushed forward with a steady, even stroke. It should be lifted slightly on the return stroke. See Fig. 158.

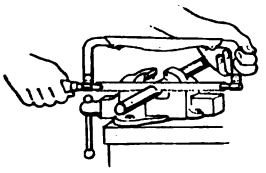


Fig. 158.

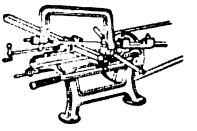


Fig. 159.

Most power hack saws are equipped with an automatic device which controlls the saw. The bar of metal is held in a vise attached to the machine which has to be opened and the stock moved forward as each piece is cut off. See Fig. 159.

145. Drilling.—A sensitive drill operated by hand with spring controlled feed is used for very small work. Wall drills, however, are excellent for general work. See Fig. 160. A drill press of the floor type (Fig. 161) arranged with power and hand feed is used for all types of boring. Radial drills are arranged with an extension arm which carries the drill head out and can be used for both plain and angular work.

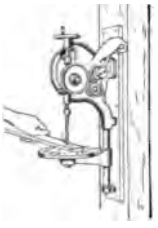


Fig. 160.

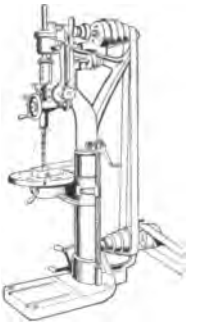


Fig. 161.

The drill should be ground with the proper clearance and to an angle of 60° for iron and steel, and 70° degrees for brass. The work should be laid out with prick punch holes for centering the drill, and put rigidly in place under the drill. It is often well to lay out a hole the size of the one to be bored; this hole to be used as a test for location. The speed and feed should be set according to the size of the drill. If the drill runs out of center at the start, it can be brought back to the center by prick punching the side of the hole nearest the center. For small holes in light work, it is often advisable to use a breast or hand drill.

146. Lathe Work.—A lathe should be used for all cylindrical work. A variety of work including straight, taper and thread cutting can

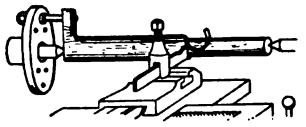


Fig. 162.

be done. After the tools are selected for the job, sharpened and the centers true and aligned, the piece is centered. Centering consists in boring and countersinking the ends of the rod to be turned so that it will revolve truly when placed between the centers. It is secured to the face plate with a dog. See Fig. 162. The ends of the piece should be faced and then the piece turned against a tool to the desired size. Thread cutting is done after the roughing cut by setting the gears properly and using the type of tool necessary to make the correct thread. See Fig. 163.

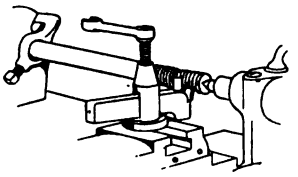


Fig. 163.

Taper turning is done by using the taper attachment or by moving the poppet head or tailstock over. It is required in various taper pins, shaftings, axles, etc.

147. Planer Work.—A planer is designed to work on large and heavy iron castings . See Fig. 164. After the machine and tool are properly placed and adjusted, the casting to be planed should be securely clamped to the planer bed or plate. The machinery is then started and the platen with the work moves toward the cutting tool which is held in a stationary holder over the platen. The tool can be adjusted to come in contact with the work which causes the surface to be smoothed. The tool automatically moves across the work and on the return stroke it lifts and rides free, thus protecting it against unnecessary wear.

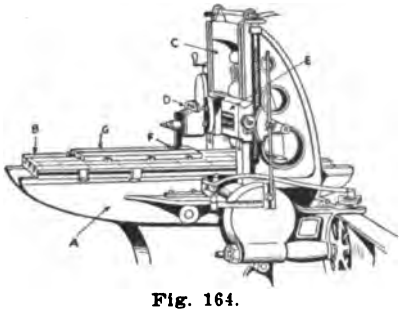


Fig. 164.

148. Shaper Work.—In the operation of the planer, the work moves against the tool while in the shaper the tool moves against the work. The shaper is particularly suited to light work and where lighter cuts and more speed can be used. See Fig. 165. The work is fastened in a vise attached to the machine and the tool is lowered to come in contact with the work. As the work progresses, the tool can be made to move across the face of the work automatically and to feed against the work

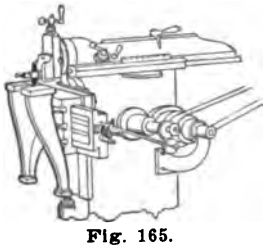


Fig. 165.

at the same time. It is necessary to see that the surface of the work to be cut is arranged parallel with the movement of the tool.

149. Milling.—The milling machine is by far the most useful of all machine shop tools. See Fig. 166. It can be used for a great variety of work, including many types of work formerly done by hand and upon other machines. The multiple-tooth milling cutter has a great advantage over the single cutter of the shaper and planer. Both plain and universal millers are in extensive use, but work of a greater variety can be done on the universal milling machine. The **knee** which supports the saddle giving the in-and-out feed movements moves up and down the **column.** The **platen** gives the traversing feed and is supported by the **saddle.** The work to be milled is carried between the **index head** and the **tail stock,** both of which rest in the platen.

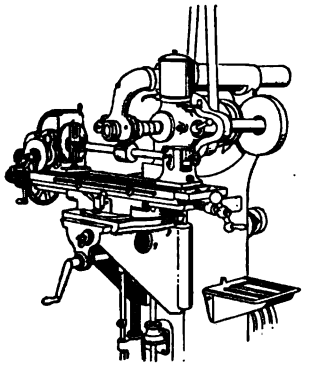


Fig. 166.

The work is fastened in position and cut as desired by the milling cutter, selected for the job, which revolves on the **arbor.** It should be located as close as possible to the column. By the use of the index head, any kind of taper work can be done. Spirals and gears of all types can be automatically and accurately cut.

Different cutters can be selected for different work as well as special arrangement of speeds and feeds.

150. Grinding.—Grinders of many kinds are used for both rough and finished work, from smoothing up rough castings to the taper and tooth grinding of thin tools. See Fig. 167. To secure the best work, the abrasive wheel must run true and the face of the wheel must be even and perfectly shaped. The speed of a grinding wheel should not be over 5,000 feet per minute. The abrasive wheel should revolve against the work being ground. A dry grinder of coarse quality is used in rough grinding, while for finishing and polishing an automatic machine equipped with fine abrasive wheels often running in water or oil is used. Grinders are especially built for sharpening twist drills, saws, milling cutters, and similar work.

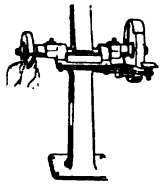


Fig. 167.

In automatic grinding, the work is held in a device attached to or in connection with the grinder.

FORGING

151. Making a Fire.—For good clean forge work, a proper fire is essential. To build a fire, the ashes and cinders should be raked off the tuyere iron, a few shavings placed in the hole just made and ignited. A little good forge coal should be put on the shavings and the blast turned on gently. As the fire burns and the smoke becomes less, the space around the fire should be banked with coal and kept wet. As it burns quickly, the gas escapes and coke is gradually formed around the fire. This is pulled into the fire as needed and the bank increased. The fire should be well centered in a small spot all the time and not allowed to spread. See Fig. 168.

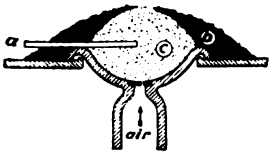


Fig. 168.

152. Drawing Out Iron.—Much forge work involves taking a bar of iron and drawing it out to a smaller dimension. The end to be drawn should be placed in the center of a good fire and heated to a good red color. The cooler end should be seized by the tongs and the hot end placed on the anvil where it can be hammered with solid blows. See Fig. 169. Hammering as at **a** in Fig. 169 increases width and as at **b** increases length.

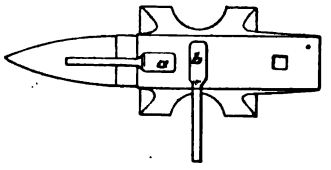


Fig. 169.

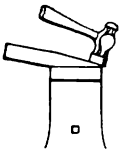


Fig. 170.

The blows should begin near the end of the stock and continue up the piece of stock by striking alternately adjoining faces. Fig. 170 shows correct method of drawing to a point. Note the position of work on the anvil.

153. Squaring Iron.—A round bar may be squared by hammering. A top and bottom face is first made by hammering along its length. Then the bar is turned ¼ way around and the other sides hammered to shape. It is best to finish all sides at the same time, using alternate blows on the different surfaces being formed. A piece of stock being squared will occasionally become diamond shaped. It can be squared by holding one face flat on the anvil and striking blows on the acute angle arris. See **a** and **b** in Fig. 171.

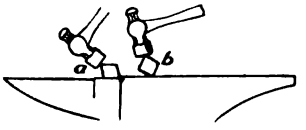


Fig. 171.

154. Bending.—Pieces of square or round stock may be bent to angles, circles or irregular forms.

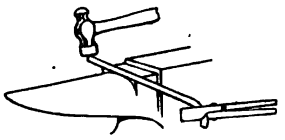


Fig. 172.

Flat pieces to be bent at an angle should be held in the tongs and bent over one edge of the anvil. To bend a circle from a piece of round stock, it should first be measured and cut off. Then, it is heated to a cherry red for about half of its length. By holding the cooler end securely in the tongs, the other end can be gradually hammered around the horn of the anvil. See Fig. 172.

When a half circle is completed, the other end should be heated and the operation repeated, thus making a ring.

155. Upsetting.—The method used to increase the diameter, or width and thickness, of a piece of iron is called "upsetting." After heating the stock to a white heat, it should be grasped with tongs and held end up on the anvil where the hammer can be used to strike the end of the piece. See Fig. 173. By repeating this method with the stock at white heat, it will gradually become shorter and thicker. If the stock bends and the ends grow thicker than the middle, it can be remedied by putting each end of the piece quickly into water and striking it again on end before the middle cools. Other methods of upsetting are shown in Figs. 174, 175, 176.

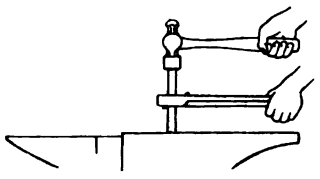


Fig. 173.

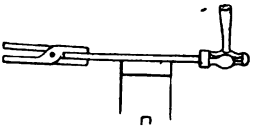


Fig. 174.

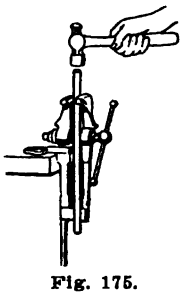


Fig. 175.

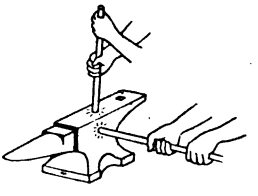


Fig. 176.

156. Twisting.—Twisting is required when it is necessary to face the opposite ends of a piece of stock in different directions. Also, it is used for ornamental purposes. A piece to be twisted should have the portion to be twisted laid off with punch marks.

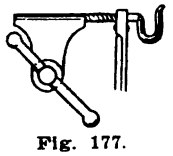


Fig. 177.

This part is then heated to a dull red, one end is grasped at one punch mark with tongs and the other

end fastened in a vise at the other punch mark and the tongs are then swung around to make the proper twist. See Fig. 177. This must be done quickly to prevent the iron from cooling before the operation is finished.

157. **Forming.**—Forming consists in shaping pieces of stock into articles such as hooks and also in making heads on nails, bolts, etc. There are two methods used to form the heads of bolts and nails. One is done by taking a large piece of stock and drawing it out from a shoulder small enough to enter the heading tool. The other is by upsetting to get the material for the head which is usually done in making bolts. When the stock is shaped correctly, it can be put in a header and the head finished.

To form a hook which requires more metal in certain parts, as for the eye, and center of the bend, it is necessary to use both upsetting and drawing. After it is upset and drawn out to size it can be bent in shape over the edge and horn of the anvil.

158. **Chamfering.**—The sharp edge of a forged article can often be improved by chamfering. It should first be marked with a prick punch, heated on the arris to be chamfered, and then held securely on the anvil while the chamfer is hammered in.

159. **Punching.**—A piece to be punched should be heated to a red color after the location for the hole is marked. Then it should be placed on the anvil and the punch driven in until a dark spot appears on the under side, when it should be reversed and the punch driven through from the other side. See Fig. 178.

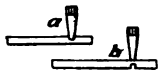


Fig. 178.

The punching should be done over a hole in the anvil or some other metal in order to allow the waste metal from the punched hole to fall out. To give the hole a uniform diameter, a drift pin of the proper size should be driven through.

160. **Cutting.**—Cutting stock into pieces and removing waste ends of finished work requires the use of the hardie or the chisels. To cut a piece at a given point, it may be marked first with a punch or by measuring it with the square after it is placed on the hardie. A light blow from the hammer in that position will mark it. The piece should then be heated, held on the hardie and all sides or faces cut under blows from a hammer. Then it may be broken by a blow from the hammer while it is held on the edge of the anvil

or reversed on the hardie. See Fig. 179. For heavy cutting, it is necessary to lay the piece of stock on the anvil and use a cold or hot cutter and a heavy hammer. A piece should be cut first from one side and then from the other by reversing the stock. See Figs. 180 and 181.

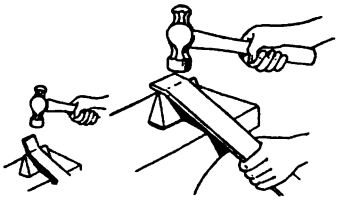


Fig. 179.

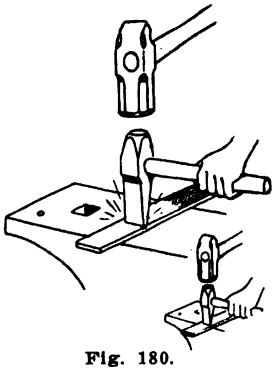


Fig. 180.

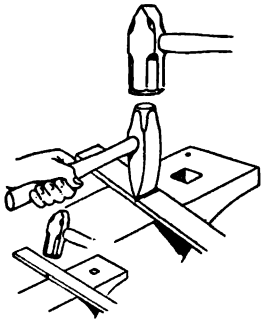


Fig. 181.

161. Scarfing.—In order to make a weld, it is necessary to shape the two ends to be welded so they will form a smooth joint. This method is known as scarfing. The ends of the pieces to be welded should first be upset to thicken the metal, and provide for the waste in heating. See Fig. 173. Each piece is then held on the anvil and drawn to a bevel chisel edge, if the metal is square or rectangular. If it is round, the scarf should be drawn to a point. See Fig. 186. The length of the scarf in either case should be about as long as one and a half times the thickness of the metal.

162. Welding.—Welds are made in straight joints, right-angle, T-shaped and circular. The scarfs should first be properly fitted,

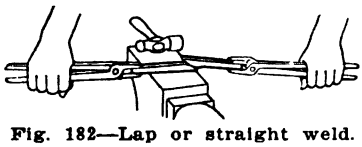


Fig. 182—Lap or straight weld.

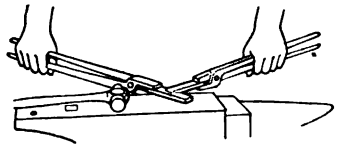


Fig. 183—T-weld.

in which condition only the center of the scarf will touch leaving the edges open. Where two ends of the same piece are brought together for welding, as in a ring or link, the scarfs should rest on each other when they are put in the fire. In welding two separate pieces of iron, they should be put in a good clean white heat. They are then removed, jarred to remove dirt or scale, and placed one scarf

upon the other by turning one over. They must be brought together quickly and hammered rapidly to make the weld before it cools. It

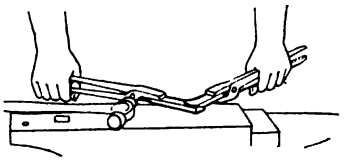


Fig. 184—Right-angle weld.

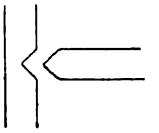


Fig. 185. V-weld.

Fig. 186. Circular weld.

can afterward be reheated and shaped to correspond in size with the other parts of the piece. See Figs. 182, 183, 184, 185.

163. **Tempering.**—Edge, face and spring tools are hardened and prepared for use by tempering. The process involves the heating and cooling of the metal to obtain the degree of hardness desired. A forged tool can be tempered by heating two-thirds of the part forged to a cherry-red heat, then cooling about one-half of the forged part by moving it around in cold water.

One side is then quickly brightened on an emery block and carefully watched as the heat in the upper part of the tool reheats the end, thus causing various colors to appear on the polished surface. As the heat moves down the tool and the proper color shows on the edge or point of the tool, it is plunged into water and allowed to become cold. Lathe tools require a light straw color, center punches purple, screwdrivers light blue, and cold and cape chisels dark blue. After tempering, the tool can be ground to a cutting or working edge.

164. **Riveting.**—When two pieces of metal are to be fastened together and it is not advisable to weld them, they may be riveted. This is done by first drilling or punching holes through each piece to coincide. The holes may be drilled through one piece and the holes in the other marked from the first, or the pieces may be clamped together and holes put through both pieces at the same operation.

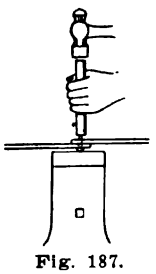


Fig. 187.

Rivets are then dropped in place and either a ball pein hammer or a rivet header used to spread the rivets. See Fig. 187.

TOOL AND INSTRUMENT MAKING

165. Special work can be done with standard tools and instruments, but increased production, accuracy and facility in operation can be

obtained by the use of special tools, jigs and instruments. They include all types of measuring and spacing devises, forming tools, threading tools, gages, reamers, and various machine tools.

166. Laying Out Tools.—All tools to be constructed should first be layed out by the draftsman to full scale, if possible, so the mechanic can work directly from the drawing.

The layout of an edged tool depends largely upon the form of the cutting edge. The exact shape of the tool is traced on the metal before it is roughed out. A true surface is necessary upon which to layout most tools.

167. Annealing.—Steel is annealed by heating it to a low red heat and cooling slowly. It is a process of eliminating the strains caused in the steel by rolling or hammering.

If properly done, annealing improves the grain of steel. Annealing is done largely in a special annealing furnace where temperature can be regulated. One method of annealing is to pack the steel in charcoal or ashes in a cast iron annealing box which is sealed in clay to retain the heat and allow the steel to cool slowly. In water annealing, the steel is heated to a low red heat. After it has cooled until it does not glow, even in the dark, it is placed in water. Or, when it fails to spark wood when held between dry boards, it is at the correct temperature for placing in water.

168. Shaping and Forming.—Tools are sized and shaped by forging after they have been heated. They are also formed and cut to size and shape by the shaper, milling machine and grinder.

Forging tools requires that the pieces be uniformly heated throughout. The hammer blows must vary with the size of the piece and as the heat vanishes. Hammering with care improves a piece of steel by increasing the density of the grain. It may be necessary to hammer only a small part of the tool and this produces a strain which can only be remedied by annealing. Tools and instruments can be shaped on machines by the ordinary method of operation.

169. Hardening.—As steel is subjected to severe strains during the heating and forging process, its structure may be altered somewhat. It can be restored to the proper structure by hardening. Tool steel hardening is best accomplished by heating the metal in a gas furnace or a lead bath, altho it can be done by a specially arranged forge fire, after which it must be cooled. The steady heat of the gas flame under air from a blower gives a good uniform heat.

For heating small pieces, a lead bath, arranged by having the lead melted in a crucible to a temperature of about 1200°, should be used. The pieces should be dry when put in the bath and the lead should be stirred while they are in it.

The cooling bath is usually of water, oil or a combination of the two. A large bath in which the water or oil can be agitated is preferable to a small one. The more rapidly the heat leaves the steel, the harder the steel will be. An oil bath tends to make the steel less brittle and, although the hardening power is less, the steel will be stronger than that hardened in water. Reamers, milling cutters and edge tools should first be dipped into water or brine and then plunged into the oil to cool. Oil and water are used together when the piece requires hardness but is liable to crack with sudden cooling. When all hissing in the bath ceases, the tool is as hard as it can be made.

170. Tempering.—Hardening tool steel makes it extremely brittle and subsequent heatings, called tempering, may be done to remove the brittleness and toughen the metal. It is accomplished by heating the hardened steel to 412° when colors will begin to show. As the heat increases, the proper color shows for the special tool being made and, when this color appears, it should be cooled. The proper color varies from a light straw color for highly tempered tools to a greenish grey color for soft tools easily filed. Special tempering is done in prepared tempering baths of heated oil, equipped with thermometers. Hot sand is used for tempering a number of small pieces at a time and metal tubes which have been heated can be used to temper slender tools and instruments.

171. Grinding and Finishing.—After the tools have been laid out, formed, hardened, and tempered, they are made ready for use by grinding and polishing. The grinding should be done on wheels especially adapted to the work. Tools used for accurate work should be tested carefully for required shape and size. The rough and dark parts of the tools should be polished in which condition they can be kept more easily free from rust.

SHEET METAL WORK

172. Pattern Drafting.—In the construction of most articles, the sheet-metal worker has a drawing, giving in detail the exact dimensions from which to work. With a knowledge of reading drawings

and blue-prints, he can obtain all dimensions required in the construction of the object. Most problems to be constructed from sheet metal require drawings of not only the plans and elevations but also a correct development in which the object is shown in an unfolded position. See Fig. 52, Sec. 5.

Where the size will permit, and it is practicable to do so, the drawing should be made full size. For the construction of simple or plain objects, it is not necessary to prepare a drawing on paper, but the mechanic can proceed immediately to lay out the project directly on the metal by the use of the steel square. In the "layout on the metal" a drawing of several views is omitted and the sizes and outlines are laid out as they appear in the development. The working drawing on paper should be made with the aid of the drafting board and drawing instruments. In laying out the pattern for an object, it is necessary to take into consideration the properties of the material used in the construction. Allowances must be made for bends in the materials and for locks, edges and laps.

173. Cutting out the Work.—After the pattern has been developed and transferred to the sheet metal and properly marked, it is ready to be cut out. Patterns are cut from sheet metal by the use of the hand, bench and squaring shears. To cut metal with the hand shears, the metal should be held in the left hand in such a position as will allow the right hand to operate the shears and make a continuous cut. See Fig. 188. Circular shears can be used to advantage in cutting small circles and various shaped openings. For heavy material the bench shears should be used. The squaring shears, which are operated by foot or motor power, are ordinarily used to square sheets of metal and to make straight cuts. See Fig. 189. Patterns containing both curved and straight lines should have the straight lines cut first with the snips or upon the squaring shears and finished by cutting the curves with the snips.

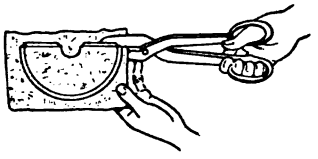


Fig. 188.

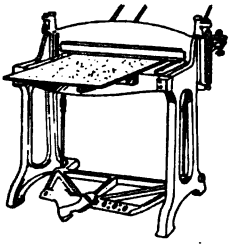


Fig. 189.

174. Folding.—In the making of seams in sheet metal work, the edges first have to be folded. This process consists in bending the

edges with an adjustable bar folder. The gage should be set to make the desired sized lock or folded edge and lock. The wedge screw should then be adjusted to form the proper lock, while the folding bar is held at a little more than a right angle with the folding blade edge. The metal can then be put in position and folded by pulling the folding bar forward with the handle. See Fig. 190. A sheet iron folding machine can be used for work which does not demand uniformity and accuracy. For seaming pipe, where the process involves first rolling it into a cylinder and then making a lock seam, the pipe-forming machine should be used. See Fig. 191.

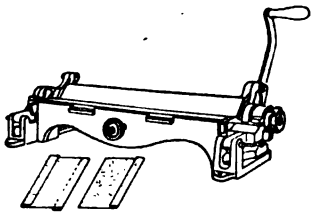


Fig. 190.

175. Rolling and Forming.—A forming machine must be used to roll sheet iron into cylinders such as stove pipe, tanks, cans, elbows, etc. The rolls of the machine should be adjusted to make a cylinder of the desired diameter after which the metal is fed between the rolls as the handle is turned. See Fig. 191. The slip roll machine permits work to be slipped off from the end of the front upper roll and thus keep its rolled shape which is not possible in a solid housed machine. This type machine is also valuable in forming a cylinder after the edge is turned. For tapered work such as funnels, lamp shades, etc., a funnel forming machine fitted with tapered steel rolls should be used. Fig. 192 illustrates the square box and square pipe forming machine and examples of work done on it.

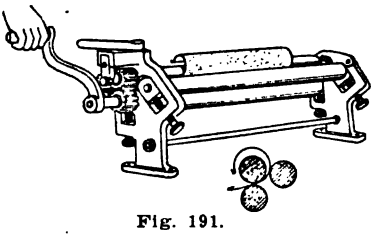


Fig. 191.

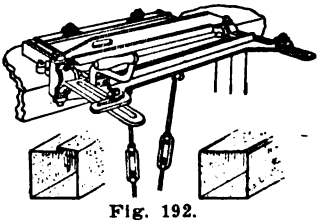


Fig. 192.

176. Turning and Wiring.—A turning machine is used to prepare the edge of a cylinder to receive a wire. The cylinder should rest on the lower roll, the edge striking the gage which should be adjusted to allow material for covering the wire. The upper roll should be depressed by turning the crank screw. The rolls are then turned and lowered gradually until a deep groove is formed to receive the wire. See Fig. 193.

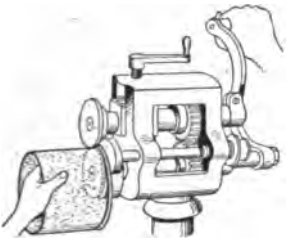


Fig. 193.

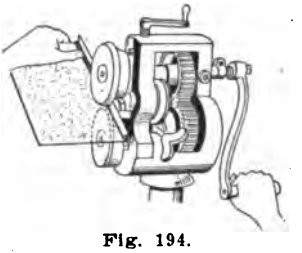


Fig. 194.

The wire is shaped by first running it through the forming machine to make it into a circle of the correct diameter. It is then slipped into the seat prepared by the turning machine and held in place by closing the metal with a mallet after which it should be run through the wiring machine properly adjusted. The upper roll is gradually lowered as the handle of the machine is turned until the metal is evenly and completely closed around the wire. See Fig. 194.

177. Crimping.—In order that two sheet metal pipes, such as stove pipe, may fit together, it is necessary to crimp one end. A bead is usually made next to the crimp to prevent the joint from slipping beyond the beading impression. The pipe to be crimped is laid over the lower rolls, with one edge against the gage, in which position, by means of adjusting the rolls and turning the crank, the crimping can be done. The work should be guided with the left hand. See Fig. 195.

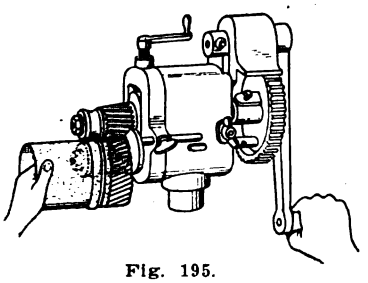


Fig. 195.

178. Seaming.—Seaming consists in fastening two edges of sheet metal together. The lap seam is made by laping one edge over the other to a distance of about $\frac{1}{8}$″ to $\frac{3}{8}$″ and riveting or soldering them together. See A in Fig. 196. The folded seam is made by turning

single edges on the metal and hooking them together after which they should be hammered down with a mallet. See B in Fig. 196. Seams of pipes and flat work can be closed completely and smoothly in this manner. The grooved seam is used largely in joining the edges of light sheet metal. The edges should be turned first and hooked together after which they should be laid on the horn of the grooving machine and the rolls run over the seam. The offset made in the upper sheet prevents the seam from coming apart and makes one side even. See C in Fig. 196. The seam is finished by placing it on a mandrel stake and pounding it tight and smooth with a wooden mallet.

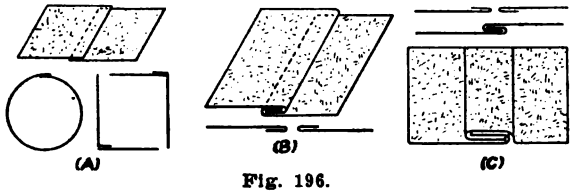


Fig. 196.

179. Beading and Grooving.—Sheet metal articles can be reinforced by beading upon the beading machine. Pipe of large diameter requires beads close together near the ends of the cylinder. After the gage is set at the proper distance from the beading rolls, one end of the pipe is inserted between the rolls, the edge resting against the gage. The machine is then turned and the hand screw on top of the machine is turned down until a proper bead is made. See Fig. 197.

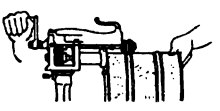


Fig. 197.

Grooving is required to make the seams in pipe. It can be done by a hand groover and mallet over a mandrel stake or upon the grooving machine. To use the grooving machine, the cylinder is put over the grooving horn and held in place against the adjustable stop. The carriage is then moved forward, allowing the grooving roll to run over the seam lengthwise. See Fig. 198.

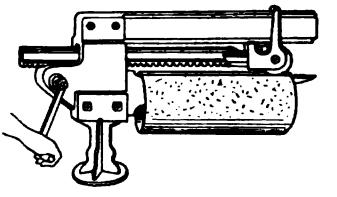


Fig. 198.

180. Use of Cornice Brake.—In the construction of gutters, cornices, spouts and other large work requiring bends of various shapes, the cornice brake should be used. The operation consists in placing the sheet metal which then remains stationary and bringing the clamping bar down with pressure applied to the foot treadles. Cam levers hold the material securely. The

bending leaf is then forced down, making the desired fold. Wooden forms are used on the bending leaf to form circular and semicircular bends. The shaping of irregular bends over the wooden form on the bending leaf is usually done with the hands. Attachments are used on some machines to do the circular forming automatically.

181. **Riveting.**—It is often desirable to fasten two pieces of sheet metal together with rivets. After the metal is properly placed, holes should be punched or drilled through at the desired points. The rivets should then be inserted and, with the rivet head held on a metal block, a riveting hammer should be used to spread the end of the rivet. To secure a smooth job with even riveted work, a rivet set should be used. The rivet set is placed over the end of the rivet to be riveted and hammered until the joint is tight.

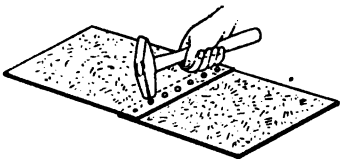


Fig. 199.

182. **Soldering.**—The welding together of two pieces of metal by means of another metal with the aid of a hot soldering copper (soldering-iron) and a flux is called soldering. Flat seams are made by lapping the metal, usually $\frac{1}{2}''$ to $\frac{3}{4}''$ and applying the flux so it enters the seam. Muriatic acid can be used on galvanized iron and zinc, while rosin should be used on tin, lead and copper, as a flux. The seam should first be tacked with solder at short intervals, after which it can be soldered its entire length by using the heated copper on the seam and working from tack to tack. On flat, locked and grooved seams, flux should be applied the full length of the seam, solder applied as above and the copper used directly upon the seam to draw solder into the seam. The copper should not be used on the edge of any seam but directly over and covering the entire width of the seam. See Art. 23, Sec. 6.

PLUMBING AND STEAM FITTING

183. **Plumbing and Steam Fitting** consist of the installation or repair of pipes, connections, fixtures and equipment which make up complete systems for carrying steam, water, gas, air, etc., in the home, factory and other buildings. Although plumbing and steam fitting are different trades, both have many things in common. Also, similar materials and tools are used for both. Therefore, they will be considered under one heading.

184. **Taking Measurements.**—The "roughing-in" of a system of steam pipes or plumbing requires accurate measurements. It is necessary to follow the plans and specifications carefully, keeping in mind at all times the codes governing the installation of each . All pipes must be located so as to be near the various fixtures and equipment, and thus guard against having to make changes after the floor is laid, or after the partitions and walls have been covered. As each pipe branch and connection has a certain function to perform, accurate measurements are necessary.

The location and description of the pipe should be obtained from blueprints, but measurements must be made ordinarily on the job and from the work itself, as the installation progresses. The measurements are usually made with a tape or extension rule. In measuring the length of pipes, the amount necessary for the joint must always be taken into consideration.

185. **Cutting Pipe.**—Soil pipe, which is heavy cast iron pipe, can be cut with a special three-wheel-cutter, but because the pipe is not of uniform thickness and is often cracked by that method, a diamond point cold-chisel and a hammer are generally used. To cut a pipe after it has been measured and the cutting point marked with chalk, it is placed on a narrow piece of wood on the floor and the cutting done with a chisel and hammer.

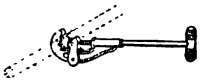


Fig 200.

A lead pipe, which is soft, should be held firmly by hand against a block nailed to a board and cut with a hack saw.

To cut an iron pipe used for carrying steam or water, it is first fastened in a pipe vise and cut at the point marked with a pipe cutter, which consists of three cutting wheels in an adjustable handled frame. As the cutter is revolved about the pipe, the handle which regulates the adjustment is gradually screwed down, causing each revolution of the cutter to cut a little deeper, until the pipe is cut through. See Fig. 200.

186. **Cutting Threads.**—Pipes which require threads on the ends, to make connection with couplings, elbows, valves, tees, crosses, etc., are ordinarily threaded by two methods, hand and machine.

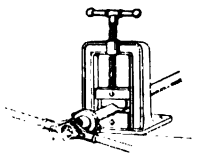


Fig. 201.

Cutting threads by power is done on a special thread cutting machine similar to a lathe, where the pipe is run in through the head stock, and clamped to the moving part, which is controlled by gears. As the pipe revolves, it comes in contact with an adjustable thread cutting die, which is held stationary in the tail stock.

In cutting threads by hand with a pipe stock and die, first the pipe is fastened in a pipe vise, allowing the end to project through far enough to receive the stock. The proper sized die is selected and adjusted in the stock, after which it is placed on the pipe and turned gradually, with half strokes. As the cutting proceeds, oil is applied to make the work easier and the threads smoother. See Fig. 201.

187. **Making Connections.**—Pipes of various types are connected in different ways, as, by the use of threads in steam and water pipes, by wiping in lead pipes and by filling the joints of soil pipes with melted lead after caulking with oakum.

Threaded pipes and connections are made by the use of a pipe vise and a pipe wrench or the use of two pipe wrenches. One part is held secure in a vise or with a wrench. The threads are then covered with white lead, or similar substance, and the other pipe or connection started in place. A pipe wrench is then used to screw the parts tightly together. See Fig. 202.

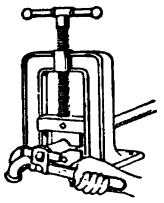


Fig. 202.

Soil pipe joints are first placed together and caulked tightly with oakum in the space provided for the joint. A space of one to one and one-fourth inches should be left in which to pour melted lead from a ladel. After the lead has cooled, it should also be caulked with a light hammer and chisel, taking care not to use pressure enough to crack the hub.

A horizontal joint can be made by clamping an asbestos runner tightly around the joint, leaving only an opening at the top large enough in which to pour the hot lead. A joint should always be filled with lead at one pouring.

188. **Wiping Joints.**—Wiping joints consists in making a horizontal, vertical or branch joint, by fitting the pipes together and coverng them with wiping solder. In making a simple horizontal wiped joint, the two ends are rasped square, and cleaned for a short distance from each end. One end is tapered about one-half inch back from the end and the other end expanded into a cone shape. The tapered end is placed in the cone shaped end and the edge of the cone hammered over slightly. At the edge of the part cleaned, a mixture of lamp black and glue, or similar materials, is placed around the pipe to prevent the solder from sticking, except at the cleaning. This is called soiling. The joint is cleaned up with a shave-hook, cutting rather deeply at

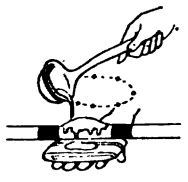


Fig. 203.

the beginning of the cleaning so there will be a slight thickness of solder at the edge of the joint.

The wiping pad or cloth should be thick enough to prevent finger impressions on the joint, but thin enough to bend to the shape required.

The pad is held under the joint and the hot solder poured on, after which it is patted round with the cloth. See Fig. 203.

The wiping should then be done by drawing the cloth upwards around the pipe and gradually forming the joint. When finished, the joint should be clean, smooth and well formed. The cloth should always be held under the point where the solder is poured on to catch the solder which runs down and to press it up against the pipe. A hot iron in one hand should be used to keep the solder in workable shape while the other hand with the cloth is used to wipe around the joint, until it is finished.

Before commencing to wipe a joint, it should be firmly set, the cleaning well done, the junction of the ends well made, so that solder will not run through into the pipe, the pipe should be dry inside and out, the solder hot enough, and the wiping cloth in good condition.

The solder should be poured on quickly to sweat the two surfaces together.

189. Packing Joints.—Faucets, valves, water and steam pump valves, piston rods, engine valves, unions, manholes and other connections, with packing in joints subject to wear and decay, must be packed from time to time to prevent loss of water and steam. The joint must first be opened, after the water or steam pressure has been cut off, by removing the bolts, set screws or union caps. All old packing and gaskets should be taken out and the joint cleaned by wiping or scraping, if necessary. The joint is then properly packed with specially prepared packing gaskets, as leather, asbestos, rope, wick packing, hemp, lead rope and rubber. The joint should be tested for leaks before leaving the job.

190. Covering pipes.—Pipes carrying steam and hot water are covered to prevent loss of heat, and pipes carrying water are often covered to prevent sweating, dripping and freezing. Asbestos, magnesia and wood-felt sectional pipe coverings are generally used, and are placed around the pipes and made secure with metal bands. See Fig. 204. Asbestos cement is mixed to a paste form, and is used to cover furnaces, stoves, heaters and often pipes, but is not as satisfactory or as easily applied to pipes as the cylindrical covering sections.

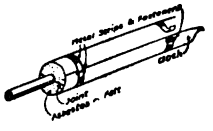


Fig. 204.

ELECTRICAL WORK

191. Electrical Work may be divided into three types: (1) House wiring, which is the wiring arrangement in houses, giving electric service for lights and outlets for the installation of electrical utensils, equipment and appliances; (2) Bell or annunciator wiring for bells, buzzers, clocks, annunciators, burglar alarms, door openers, gas lighters and like devices; (3) Installation of electrical equipment and machines, including switch boards, meters, motors, elevators, transformers, motion picture machines, telephones, telegraph and wireless outfits. Important things common to all electrical construction work are means and methods of running wires, the proper protection against damage to wire and the building and operative appliances.

192. Wiring.—In wiring a building, care should be used in open work to insulate all wires and prevent them from coming in contact with materials other than the insulators. Wires run open should be at least No. 14 B. & S. gage and should be properly supported with knobs, cleats, circular loom or tubes. If the wire is run in a conduit, which is the best method, it should be double braided and rubber covered. All service wires should be run into a building through a gooseneck, service head, or other arrangement to allow the wire to hang in a loop below the opening and thus protect it from rain. In a new building, the wires may be easily attached to the interior of the frame construction, but in an old building it is necessary to remove the floors and make openings in the walls so the wires and conduit may be fished through.

Fishing is usually done by making a hook in the end of a wire and pushing it through one opening, while another wire is prepared in the same manner and put through an advance opening where it is twisted and moved around until it catches the hook on the first wire. It can then be pulled through.

All electric wiring must be done in accordance with the National Electrical or local municipal code. A standard type of construction and standard materials must be used. Portable devices require cords. Drop cord is used for lamps. Heater cord, which is slow burning, is used in high temperatures and reinforced cords are used where they are subject to rough use, as in a garage. Lead covered wires are used underground as a protection against moisture and chemical action. Flame proof wires will not ignite. Rubber covered wire is for inside use and weatherproof wire is especially treated to withstand outdoor requirements. Fixture wire, which is usually No. 18

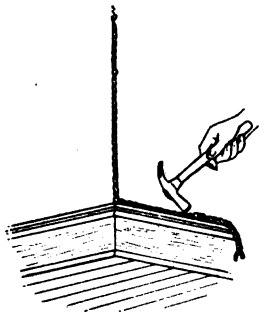


Fig. 205—Running wires for electric bell.

gage, is used for the wiring of fixtures and some appliances such as bells, burglar alarms, etc. Wiring for bells, annunciators, buzzers, clocks and similar fixtures (which receive their current from batteries, a small transformer on the lighting circuit or a small generator) is fastened in place with insulated staples and buttons. See Fig. 205. Staples and buttons should be driven with a small hammer, care being used to prevent injury to the insulation around the wire. The width of an insulated saddle staple permits two wires to be fastened under one staple. A long run should be stapled first at each end, then the intermediate staples driven in at spaced intervals. Twisted wire, like telephone cord, may be held in place with insulated nails. However, wood cleats are preferable for holding twisted or single wire.

In an unfinished house, the wires should run in the walls, but in finished houses, they can be run along or over the mouldings, baseboards, doors and window casings. For this purpose wire and nails colored to match the surroundings should be used. Bell wire should not be located nearer than six inches to a lighting circuit. Two classes of wires, as for signaling and power, may be run within two inches of each other, if one class is run in non-combustible tubing.

193. Use of Knobs.—Knobs are of two types, common and split. Ordinarily, they are made of porcelain and are used in open work. They are fastened to the studding and beams of buildings with screws or common wire nails, a leather button being used under the head of each nail. The wire must be wrapped securely around the groove in the common knob to withstand all strain.

The split knob, arranged with 2 and 4 slots, to hold the wire between the two parts, is largely taking the place of the common knob. See Fig. 206.

194. Tubes made of porcelain are used in running wires through the studding, joints and other timbers of a building. The hole through which the tube is inserted is bored first, the tube inserted and the wires run. See Fig. 206. To bore holes through joists which are close together, a special chain ratchet brace is used. A porcelain tube may be broken squarely when desired by heating it at the right place to be broken in the

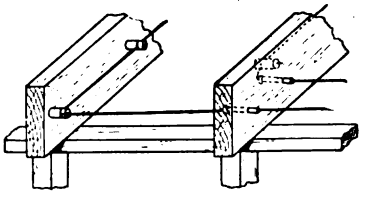


Fig. 206.

flame of a blow torch and thrusting it into water. The sudden cooling will check it at the place where it was heated and it can easily be broken at that point.

195. Cleats are used to hold wires at the proper distance from each other as required by the code. Wires should be placed in the grooves between the two parts of the cleat and fastened in place with screws or nails with leather under the heads. See Fig. 207.

Fig. 207.

196. Use of Conduit.—Conduit is of two forms: flexible, which is a tube of spiral steel, and rigid, which is a pipe. Both types are used to enclose wiring for electric work. Flexible conduit is used in both old and new buildings but is especially adapted to old structures because it can be fished. Flexible conduit should be put up securely in continuous runs, with a junction box, or outlet, wherever service is desired. Where it is impossible to make a good bend with rigid conduit, the flexible may be used. See Fig. 208.

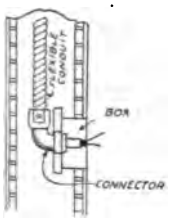


Fig. 208.

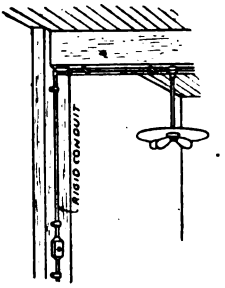


Fig. 209.

Rigid conduit (Fig. 209) should be used wherever possible, but around beams, stairways, and in difficult locations, it can be used to advantage in combination with flexible conduit. See Fig. 210. As with the flexible conduit, the rigid conduit must be continuous from one outlet to another. When the continuous run is longer than the conduit, the conduit should be joined by means of a pipe coupling.

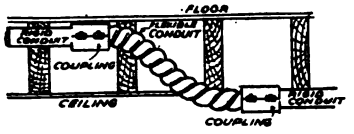


Fig. 210.

After the conduit is properly connected, it should be fastened to supports with pipe straps. See Fig. 211. A hickey is used to make the bends in the rigid conduit. Electric wires in conduit are usually double braided, and rubber covered. A steel wire is used to pull in the electric wires after the conduit is installed. One end of the wire should be fastened to the wires to be pulled through. The other end is put into the conduit and fed through to the

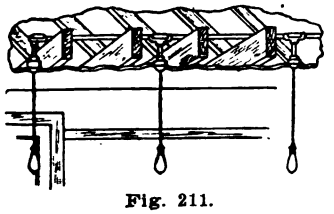


Fig. 211.

first opening or pull box. The wire is fed into one end and pulled from the other.

All metal conduit must be grounded by attaching a ground wire (usually No. 10 copper) from the conduit to a water or gas pipe outside of the meter connections. The wire should be attached to both pipes with ground clamps. The ground wires should be located safe from injury.

197. Circular Loom, which is made of a good insulating material, is used to cover wires where they cross, and thus prevent them from touching each other. It is also used to a large extent in shops to protect drop cords from injury and oil. It is placed over the drop cord just above the socket before the drop light is installed. See Fig. 212.

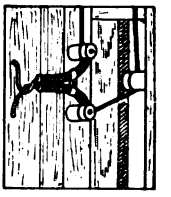


Fig. 212.

198. Mouldings of both wood and metal are used to enclose electric wires when they run on the surface, as is often done in old buildings. Metal moulding has replaced wooden moulding to a large extent and conduits are now largely replacing metal mouldings. The back of the moulding, which is one of the two parts, is first attached in place against the wall. The moulding may be attached with screws or nails. Wires are cut to reach without splicing, between two outlets, and then put in place, after which the connections are made and the cover attached. The cover is fastened by driving it down over the back of the moulding. The same wire which is used in the open construction can be used in moulding. Metal moulding should be grounded the same as conduit. See Fig. 213.

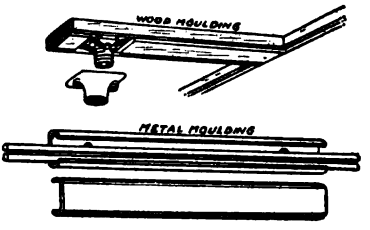


Fig. 213.

199. Attaching Push Buttons.—Push buttons like switches are used to close and break circuits, but, unlike switches, they are constructed with a spring, which automatically breaks the circuit when pressure is removed from the button. The common type of push button is usually attached through the back by means of screws, the top being removed for that purpose. The floor push button, operated by pressure of the foot, is constructed in several styles, but one common style is installed by boring a hole and driving the push

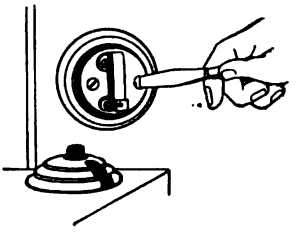


Fig. 214.

button in place. The pendant push button is used where it is necessary to change positions frequently. All buttons are arranged with two screws, to each of which one wire is fastened. See Fig. 214.

200. Locating Bells and Annuciators.—Bells are used for many purposes, and are located in different places, depending upon the use. A buzzer is used where it is desirable to eliminate the ring of the bell. The battery used to operate the bell is usually placed in the basement or at some out-of-the-way place. In attaching most bells and buzzers, it is necessary to remove the cover and then use screws to fasten the bell in place. See Fig. 215. Care should be used to prevent injury to the insulated wires. One bell wire should be attached to each post. See Art. 204 for completing the wire connections.

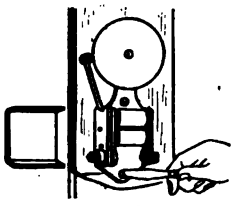


Fig. 215.

Annunciators are used when it is necessary to signal a central station from several points, and record each point signaled. They are attached (with screws) through holes, or to devices made for the purpose. Any signaling point must be in a circuit embodying the drop of the annunciator corresponding in number to the point from where the signal is sent.

Gas lighters, door openers, burglar alarms and elevator signals are installed and connected up in circuit similar to the annunciator. In the gas lighter, it is necessary to produce a spark to light the gas. The burglar alarm circuit on a window is closed by moving the window. The door opener is usually connected to a push button and battery the same as a bell.

201. Use of Switches.—Switches are used to close and break circuits. There are many forms and types of switches, but the common ones are: knife switches, surface enclosed switches, flush wall switches and pendant switches.

Knife switches include those from single pole to four pole and single to double throw. They are used as main entrance switches on switchboards, as the chief lighting circuit switches and in motor circuits. Several types of knife switches are made. Knife switches should be installed in a dust proof cabinet, if there is a chance of causing a fire by the presence of gases or inflammable materials in the room. Switches that are arranged with fuses should always be placed in a cabinet. They should be fastened in a vertical position, if possible, with the switch opening down.

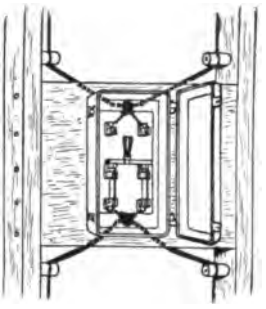


Fig. 216.

Enclosed switches are used for safety against shock, as the live metal is mounted on a porcelain base, and inclosed by a cover. They are installed on the surface or flush with it. The cover of the surface type is first removed and the other part attached with screws. The flush type snap switch, as well as the push button type, is enclosed in metal boxes, in addition to being surrounded by porcelain, and must be set into the wall and fastened with screws. The pendant switch, like the drop cord socket, is fastened to the wires by removing the cover and attaching one end of each wire to set screws provided for that purpose. See Fig. 216.

202. Splicing Wires.—It is necessary to make splices and joints in wiring jobs, both in a continuous direction, commonly known as joints, and at right angles, which is known as tapping. Although solder and tape must be used on joints, it is first necessary to make a joint that is correct. To make any joint, the insulation must be removed from all of the wire used in making the joint. It is then scraped to make it bright. See **a** and **b**, Fig. 217. The Western Union joint is made by twisting the two ends to be joined as shown by **c, d, e** in Fig. 217. A straight joint may also be made by bending each end back sharply, hooking the ends together and winding them tightly together with a separate binding wire. Tapping from a main wire is done as in **g**, Fig. 217, or by first making a half-hitch and winding a short end tightly about the main wire. Heavy stranded cables should be divided and each part wound separately about the main cable. Special splicing devices may be used without solder in joining wires together.

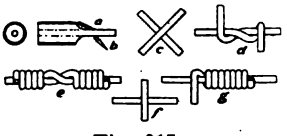


Fig. 217.

203. Soldering and Taping Joints.—After the wires have been scraped and properly joined, they should be soldered. The flux or soldering paste is first applied and then the solder with a hot soldering copper. See Fig. 218. Care should be used to see that the solder fills all the cracks between the wires and is left in a smooth condition for the entire length of the joint. The taping is done by first wrapping a piece of rubber tape smoothly over the joint.

This is then covered and held in place with friction tape. See Fig. 219.

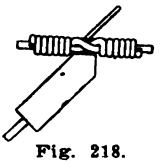


Fig. 218.

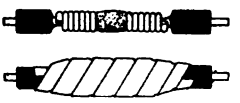


Fig. 219.

Fig. 220.
Showing method of splicing twisted insulated wires.

204. Making Battery Connections.—Batteries used to give current for operating bells, alarms, door openers, etc., when more than one is required, may be connected in three ways: series, parallel and multiple series. For series arrangement, which is the most common, the negative pole of one cell is connected to the positive of the next. See c in Fig. 221. This method increases the voltage (pressure) as many times as there are cells. If one cell gives 1½ volts, 3 cells would give 4½ volts. In parallel arrangement, all of the positive poles are connected to one wire and all the negative to another. See d in Fig. 221. This method increases the amperage quantity as many times as there are cells, but the voltage remains the same as one cell. Multiple series gives a voltage of one-half a series arrangement, and an amperage equal to the amperage of one cell, multiplied by the number of cells. The connection is made by dividing the cells into two groups and connecting each group in series. The two groups are then connected with the circuits in parallel.

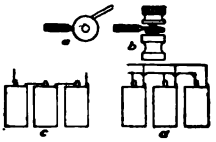


Fig. 221.

Bells and buzzers are connected by first removing enough of the insulation on the wire to make an eye or loop large enough to go over the threads on the terminals. See Fig. 221. The nut is then tightened against the wire. Stranded wire should be twisted before making the eye or loop.

205. Installation of Fixtures, Equipment and Machines.—Fixtures usually come with the wire installed. Where the wire is not installed, it must be fished through with a wire or string. Fixtures are installed with insulating joints, against the walls and ceiling and between other connections in the fixtures. When they are installed in connection with conduit or moulding, the insulation may be omitted. All fixtures before being put up should be tested with a special apparatus for grounded wires and short circuits. Drop lights are attached securely in place through a ceiling button. A knot should be tied in the wires to hold the weight of the fixture rather than to depend solely upon the connection.

All equipment and machines should be permanently and properly installed on separate circuits without depending upon the ordinary lighting circuit to carry an extra load. Heating equipment such as irons, glue pots and soldering irons should be installed with pilot lights to indicate when the current is off or on. Motors, dynamos, etc., should be installed with the shortest possible runs of wire between the service source, the switch and machine. The wires for any use should always be at least one-fourth larger than the exact requirements. All joints and connections should be carefully made, soldered and taped. The installation of electrical machinery requires the services of an experienced electrician to do the job satisfactorily. He must be able to carry out specifications in detail and know the code requirements.

CONCRETE CONSTRUCTION

206. Constructing Forms.—Forms and molds are used to hold green concrete in place while it "sets" and cures. In all concrete construction work, it is first necessary to build forms to the required size and shape, for the individual problem. Molds of steel and iron are used extensively for small work, such as ornamental pieces, tile, block and brick work, where the same design may be repeated. For individual projects, the forms must be built as required. They are usually constructed of lumber or metal or a combination of the two.

Fig. 222—Showing a wood form.

For the best results, it is recommended that green lumber be used or that dry lumber, if used, be soaked before placing the concrete. Forms may be classed as circular and rectangular. The circular forms are built to construct tanks, columns, silos, etc. They consist of an outer and inner wooden circular form, covered with sheet iron or made entirely of metal, and are usually constructed in sections. They are more difficult to build than the rectangular forms. Rectangular forms are most common in building foundation work, piers, bases for machinery, tanks and troughs. The inner and outer parts of a form must be built separately, carefully placed, leveled and plumbed. See other forms under Arts. 13 to 16, Sec. 6.

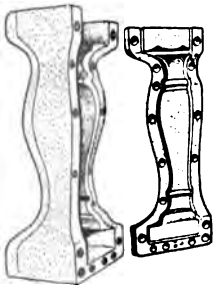


Fig. 223—Showing a plaster of Paris form.

All forms should be accurately built, with a smooth surface next to the concrete, and well braced

to stay firmly in place. Forms may be held together with nails, screws, clamps or stakes. Repeated nailing and tearing down forms causes a loss of lumber. Clamps make it possible to erect and remove forms with ease. For walks, floors and small work permanently placed, stakes may be used to keep the forms in place. Screws may be used in the construction of forms for small boxes, troughs, posts and flower pots. Plaster of Paris forms are often used for ornamental objects. See Fig. 223.

207. Proportioning.—The bringing together of the ingredients, sand, gravel or broken stone and cement into a mixture for making concrete is called proportioning. It is necessary that the coarse sand and fine materials be so proportioned that the cement will reach every particle when mixed and make a good bond. Voids, or empty spaces will occur, if the materials are too coarse, and may make a weak

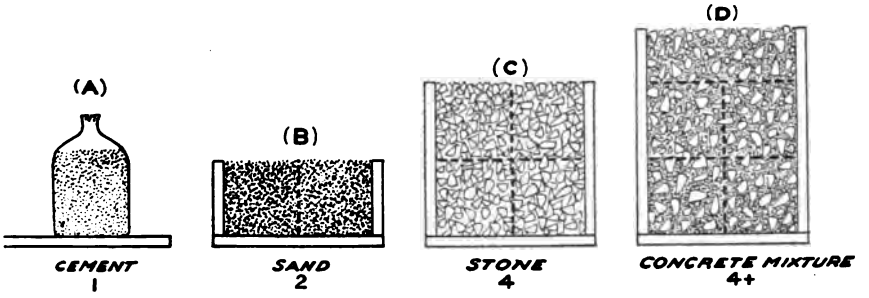


Fig. 224.

structure. On the other hand, fine sand without the coarse aggregate gives density but little strength.

Select sand that is clean and coarse. Dirt in sand may be detected by rubbing a little damp sand in the hands. The dirt will stick to the fingers. Dirt in sand will also color water when the sand is emptied into it. The coarse aggregate of stone or gravel should be carefully selected to see that there is no clay or dirt on the surface. Sand, gravel or stone may be washed on an inclined trough arranged with a screen bottom which allows only the waste dirt to pass through as it is washed down. The gravel or stone should be screened to size for use. For foundations and thick work, sizes one-half inch to two and one-half inches in diameter are used. For small fine structures, one-fourth to one inch stones are sufficient. Good Portland cement and clean water should be used.

For most work in concrete construction, the mixture should be 1:2:4, which means one part cement, two parts sand and four parts stone, or gravel. Fig. 224 shows the relative proportion of each in-

gredient. As shown, the quantity of concrete will be only a little larger than the quantity of stone. The voids in the stone are filled by the sand and the voids in the sand by the cement. For a fine, even texture on ornamental work, the proportion of cement should be increased with the coarse aggregate omitted. A mixture of 1:2:3 should be used for one-course walks, floors, steps, roofs, fence posts, water troughs and tanks. For reinforced beams, columns, floors, work subject to vibrations, and water tight work, the standard 1:2:4 mixture is used. Mixture 1:2 1/2:4 should be used for pavements, backing of concrete blocks and similar work. For supporting walls, foundations, butments, small machinery foundations, sidewalk bases, etc., the 1:3:5 mixture may be used to advantage. Mortar for facing floors, blocks, ornamental projects, walks and coats of plaster should be of mixtures varying from 1:1 1/2 to 1:3, depending upon the nature of the work.

The amount of water to be used will depend upon the work being done. Three mixtures are generally used. The wet mixture, which is mushy enough to run off the shovel, is used for thin walls and reinforced structures. Medium mixture is used for posts, poles, drain tile, foundations and floors. The thick mixture is called dry. It is like damp earth, sets quickly, and is used where concrete is tamped in place. Brick, blocks and ornamental work done in steel molds require the dry mixture. For any construction, the use of very wet, sloppy mixtures should be avoided.

208. Mixing.—After the ingredients are carefully proportioned, it is necessary that they be thoroughly mixed. Two methods are used in mixing concrete, the hand or shovel method, and mixing by machinery. The machine method is used on large jobs and where the work is continuous. Since the cost of mixing machinery does not justify its installation for a small job, the hand method is used.

A water tight mixing platform about ten feet square should be built of one inch surfaced, tongued and grooved or rabbeted boards. These should be fastened together with five two-by-four inch cleats. A measuring box holding one cubic foot is a convenient size to measure the sand and stone because it is equal to one sack of cement. The mixtures for the job are selected, then the required amount of sand is spread on the mixing board to a depth of three or four inches. The cement is poured evenly over the sand. Now with a square pointed shovel, the cement and sand are turned over and over until the streaks of cement and sand are merged into a uniform color.

The stone is added evenly and gradually to the pile of sand and cement and the mixing continued while the water is being added. A bucket or hose without a nozzle is used to add the water. It is added gently to the middle of the pile. As the mixing by turning with the shovel progresses, more water is applied to the dry spots. After it is thoroughly mixed to the proper consistency, the concrete is ready for placing.

209. Placing.—The forms should be ready before the concrete is mixed and the concrete should be placed immediately after mixing. The concrete must be carefully placed so it will completely fill the forms and be compact. It may be shoveled, dumped from a wheel barrow or poured from buckets into the forms.

In structures containing reinforcement, the concrete should be wet and poured into the forms in the method required. To prevent the coarse aggregate from being next to the surface when the forms are removed, it is necessary to use a spade or some other flat tool to push the coarse material back. See Fig. 225. In work requiring the introduction of reinforcements, as the work progresses, it is necessary to use a medium mixture and to force the concrete into place by stirring, tamping, and jarring the form as it is filled. For ordinary construction which does not require reinforcement, the concrete should be deposited in layers four to six inches thick. It should be tamped lightly and immediately spaded next to the form with a spade or beveled board to secure a smooth surface.

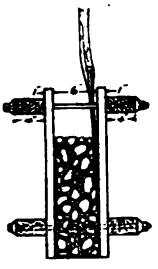


Fig. 225.

Brick, tile, flower pots, urns and similar articles are constructed in steel or iron molds from a dry concrete mixture. Pressure and tamping methods are employed to force the concrete in place. Under pressure, it is only necessary to see that the molds are completely filled with concrete, but with tamped work, it is essential that the concrete be tamped uniformly as it is placed in the mold.

210. Curing.—It is important that proper care be given concrete after it is placed. Concrete while setting, which requires four to five days, should not be exposed to the sun. Unless the form can be left in place for one or two weeks to protect it, the concrete should be wet by sprinkling at least twice each day for a week. This allows the inside and outside of the mass to dry at the same time. Old bags, carpet, canvas, etc., hung or placed close to the concrete, will aid the curing process by preventing too rapid drying.

To prevent ornamental objects, brick and blocks from cracking, they should be cured gradually. Steam curing rooms, in which blocks can be cured in two days in a hot, moisture saturated atmosphere, are used extensively. Objects cured in a closed steam curing room are stronger, of uniform color and are much less likely to be broken while drying and handling. However, small jobs are cured by wetting with water twice a day for two weeks. In about four weeks they are ready for use. To secure a uniform color, different objects should be protected from wind and should receive the same treatment.

211. **Reinforcements.**—Ordinary concrete, in which wires, rods or bars of iron or steel have been imbedded, is called reinforced concrete. Any work which may be subjected to a load tending to cause concrete to bend, jar or stretch, as in posts, columns, walls, stacks, tanks, slabs, floors and beams, must be reinforced to withstand the strain. For small work, steel rods, 3/16″ to 5/16″, should be used. They may be round, square or twisted. See Fig. 226. Wire cloth made especially for concrete reinforcement, and straight single wire are used extensively. Galvanized wire is not necessary because wire will not rust in concrete. See Fig. 227.

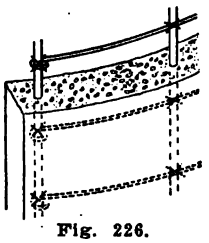


Fig. 226.

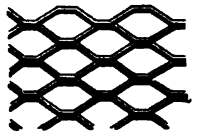


Fig. 227.

The reinforcement is either put in as the concrete is added or previous to the pouring, depending upon the job. The material for reinforcement should be put in where it will do the most good. In order to do this, it is necessary to know what the strain will be and where the load will come. Because of a strain from all directions, a fence post should be reinforced on all sides with small rods. A slab to be placed in a horizontal position should be reinforced near the bottom with woven wire fabrics. To prevent cracking in troughs, boxes and urns, any kind of single wire can be used. Invariably the steel reinforcement should be placed in the side where the pull is to come.

212. **Coloring.**—While the natural color of concrete is desired in nearly all work and although the beauty largely results from the proper selection, proportioning, mixing and form of the structure, color is often used. For floors, walks, urns, jardinieres and other ornamental work, it is sometimes desirable to use color in the concrete to harmonize it with other things.

Only mineral coloring matter should be used, and then never to exceed five per cent of the weight of the cement. Greys and black can be secured by using lampblack, black oxide and carbon black. Ultra-marine blue gives a blue shade and chorium oxide a green shade. Bright red can be obtained by using turkey red. Indian red gives darker red. Buff and yellow will result from the use of yellow ochre.

The coloring matter should be measured carefully and the quantity used based on the amount of cement. It is added to the sand or cement before any water is used and mixed thoroughly. It is turned over as sand and cement are mixed (See Art. 208) until a uniform color is obtained.

213. **Finishing.**—The beauty of a concrete job depends, to a large extent, upon the finished appearance of its surface. It must be even, smooth and of uniform finish. A spade or face cutter forced down against the form as the concrete is placed will push the coarse aggregate back, allow the mortar to fill in against the form and make a smooth surface. See Fig. 225. A mortar finish can be obtained by using a sheet of metal to divide the concrete and mortar, or by inserting a board the thickness of the mortar against the form and later removing it and filling the cavity with mortar. An open surface, like a walk, can be troweled to make a smooth finish. This is done with a finishing trowel, which, while used to level the concrete, will force the coarse aggregate down and allow the mortar to make a smooth, fine finish. An edger should be used along the forms to make a smooth edge. The joints in a walk can be smoothed and rounded with a jointer. See Fig. 29, Sec. 6.

There are several methods of finishing smooth concrete surfaces to give them an artistic appearance. The surface may be rubbed with sand and plenty of water under a float or small board when the concrete is a few hours to three days old. This time depends upon the drying conditions, but the concrete should be neither too hard nor too green. To remove the plaster like appearance, the concrete should be brushed when 10 to 12 hours old with a steel or stiff bristle brush. A solution of one part muriatic acid and three parts water is used to treat the work after brushing. A smooth surface of fine finish can be obtained when the concrete is about two days old by removing the forms and rubbing its surface with a brick and sand, carborundum, or emery. Concrete that is about one month old can be dressed similar to natural stone. A brush hammer, preferably one with four points, is used. Corners can be readily finished in this manner. On large construction work, concrete surfaces should be finished with the

sand blast. It makes a granular finish and consists in forcing sand grains from a nozzle against the surface with great force. Concrete to be treated in this manner should be at least one month old. Variations in concrete surfaces may be made by combining and substituting materials. Aggregates may be selected from limestone, colored stones, marble chips, granite or trap-rock. Expensive materials for a surface are put on to a depth of from one inch to one and one-half inches in the same way that concrete is faced with mortar by using the metal partitions. Fine aggregate produces a comparatively smooth finish. Increasing and diminishing the sizes of the aggregates, as well as materials and colors, will make a widely varying surface.

BRICKLAYING

214. Spreading Mortar.—Mortar is used to fill the spaces between the pieces of stone or brick, etc., to thoroughly cement the mass together in construction work. It is spread with a large trowel which requires considerable skill to manipulate. The mortar is taken up on the trowel, not by pushing the trowel point into the mortar, but by cutting into the mortar at an angle. To spread the mortar properly, it is necessary to have the trowel slightly tilted so the mortar leaves the trowel in an even layer as the trowel is pulled forward. It should not be shaken off nor should it all come off at once. The point of the trowel is used to further spread the mortar by a backward or forward movement of the hand as indicated in Fig. 228.

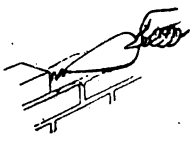


Fig. 228.

215. Pointing the Joints.—After the brick are laid in a wall and before the mortar hardens, the pointing is done. Fig. 299 shows the method. A joint that is even with the surface is called a **flush** joint. A **struck** joint is inclined backward and downward, forming a narrow shelf on the lower course of brick. When it is inclined upward and backward it is called a **weather** joint. See Fig. 229.

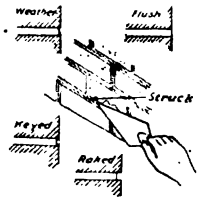


Fig. 229.

It is necessary to use a special pointing mortar in stone construction. It is applied with a pointing trowel, or metal tool which is moved forward or downward with an even stroke, the point being allowed to follow the joint. Care should be used to exert an even pressure and thus make a straight, smooth joint.

216. Breaking Brick.—"Closers," which are broken brick, are used to finish or close-in the length of a brick course.

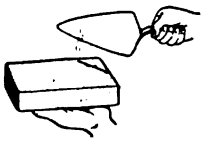


Fig. 230.

They are made by cutting the brick to suit the use. A soft brick is ordinarily cut by striking the brick sharply with the edge of the trowel. See Fig. 230. Another method of cutting is shown in Fig. 231.

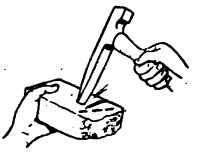


Fig. 231.

217. Bonding.—The process of laying brick across each other so one brick rests on parts of two or more brick is called bonding. See Figs. 18 and 19, Sec. 6. Headers are bonding brick placed crosswise so that only their ends are exposed in the face of the wall. Many types of bonds are used in laying brick, but the one most common in the United States is called running or garden bond. It is the fastest method of building walls and consists in laying from four to six stretcher courses and bonding with one row of headers. See Fig. 17, Sec. 6. Brick that are laid lengthwise on the face of the wall are called stretchers.

218. Testing with Straight Edge.—Courses in brick work should be tested often during the process of construction.

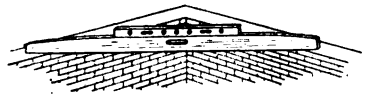


Fig. 232.

A straight edge placed in a horizontal position may be used for testing. See Fig. 232. To keep the courses of brick work properly lined, and especially in a column whose sides are slanting, a straight edge may be used in a vertical position.

219. Lining up Work.—In starting a brick structure and in running long walls, a line can be used to great advantage to keep the course straight. See Fig. 233. The ends should be correctly located and the line made secure at each point.

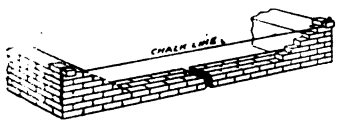


Fig. 233.

The brick should then be laid to conform to the line.

220. Use of the Plumb and Level.—As the courses are laid, they should be tested with a level and kept true. See Fig. 232.

A level can also be used in a vertical test, if it has an end glass.

A plumb-bob should be used to keep the joints and wall surface plumb at all times and in perfect alignment.

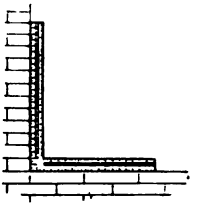


Fig. 234.

221. **Use for the Steel Square.**—A steel square can be used to test the interior and exterior corners of a building for squareness. Windows and door openings in brick walls may be tested with a square to determine the squareness of the angles. See Fig. 234.

PLASTERING

222. **Plastering** is the process of coating surfaces with thin layers of plastic material.

Plastering applied to the exterior of structures is known as stucco work. Plastering is applied to two kinds of bases, one in which the mortar is spread over a lathed surface and the other where it is applied to a stone, concrete or brick surface.

223. **Lathing.**—As a rule, wood lath is used on frame structure of non-fireproof buildings and metal lath in fireproof construction. Wood laths are cut from pine, spruce and hemlock to a standard size of ¼″x1½″x4′. They are nailed to the studding and joists in parallel rows with a space of about ¼″ between the edges. They should be flush and butt jointed. Joints should be made to break on alternate studding or joists after a surface of 15 to 18 inches has been covered. See Fig. 237. One nail is usually driven through the lath at each studding and two used in each end of the lath.

Fig. 235.

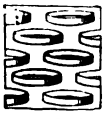


Fig. 236.

Metal lath is made in the form of wire netting, also perforated and expanded metal. See Figs. 235 and 236. It comes in rolls 32″ to 36″ wide, also in 8′ sheets of various widths. To make a good job, metal lath should be stretched tight, which can be done with a special stretcher. Metal lath is fastened in place with nails or staples.

224. **Mixing Mortar.**—Mortar is made from slaked lime, sand, hair and water with the occasional use of plaster of Paris. Except in special work on large jobs where a machine is used, all mortar is hand mixed. After a good quality of lime has been selected, it is slaked in a tight box by the addition of water. With this as a

base, the other materials are added for the various coats and mixed by stirring with a hoe.

225. **Coarse Stuff,** which is the mixture used for the scratch coat, is made by mixing slaked lime in a thin paste form with sand and hair and piling in a heap for five or six days to season. It is then mixed in small batches to the proper consistency and used.

226. **Fine Stuff** is used for the second or floating coat, and often in a little finer state for the finish coat. It is made from thin slaked lime with a little hair added.

227. **Gauged Stuff,** used for a finishing coat, is made from three-fourths plasterer's putty, which is strained fine stuff, and one-fourth plaster of Paris. It is used on walls and ceilings. The plaster of Paris causes it to set quickly.

Stucco which is used for exterior finish is made of one-third sand and two-thirds fine stuff. It is used as a thin paste.

228. **Applying First Coat of Plaster.**—Plaster is usually applied in two or three coats. For cheaper work two coats are used, the first coat being made as smooth and even as possible to receive the finishing coat. The roughing or first coat which is called the scratch coat is the foundation of a good job. After the mortar has been mixed to a consistency soft enough to be pressed thru the laths and tough enough to hold together, it should be shoveled into hods and placed on the mortar boards. See Fig. 237.

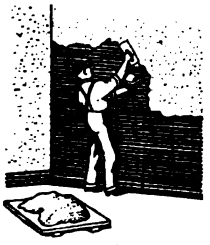


Fig. 237.

A quantity of the mortar is then put on the hand board or hawk with the hand trowel. See Fig. 237. The trowel is then used to cut a slice of mortar from the hawk and spread it firmly and evenly over the surface to be covered, to a thickness of about ¼". After the coat has dried for two or three hours, it should be scratched over diagonally with a tool of comb-like blades made for that purpose.

A second coat is called the brown or floated coat. It is applied from a fine stuff mixture to a depth of ¼" to ⅜" after the scratch coat is dry enough. This coat must be made even and true with a broad shaped trowel called a float. To prevent a rolling surface, a method known as screeding, in which plaster guide bands about 6" wide are put on at intervals of a few feet, is used. These bands, as well as the second coat, are kept about ⅛" from the face when finished.

They are put on absolutely true and plumb. The spaces in between are then coated and worked down to the same surface as the bands with a two-handed float. It is necessary to press and rub the particles of mortar with considerable force to make a close, firm layer.

229. **The Finishing Coat.**—Finishing coats are of various kinds, such as **troweled stucco, rough plaster** and **hard finish.** The finishing coats are applied to the walls in the same method as any of the other coats with a steel trowel, but to a depth of about $\frac{1}{8}''$. The mortar is made up in the form of a stiff paste to suite the job desired. After it is applied, it must be smoothed and polished with the steel trowel, keeping the surface moist as the work progresses.

BRICK AND TILE MAKING

230. The methods and materials used for making brick and tile are practically the same. The work consists in the mixing of clay and water, and shaping on a machine, drying, burning and cooling the mixture.

231. **Mixing Materials.**—Clay which is obtained from the earth in a natural state is the principle material required for making brick. The clay is screened to remove stones, etc., and then mixed with water. Originally, when bricks were made by hand molds, the clay and water were hand mixed, but they are now mixed and worked to the proper consistency in a pug-mill. The clay is mixed into three conditions which are soft-mud, stiff mud and dry clay.

232. **Shaping.**—When molds are used, the clay is mixed to a plastic state, pressed into molds, allowed to set a short time and then removed for drying and burning.

A machine, which requires soft mud, presses the clay into molds by a plunger. The molds can then be moved forward and the brick cut off by hand or with a special tool.

The machine most largely used for making brick requires a stiff-mud mixture. The clay, properly mixed, is fed into the brick machine, and from there it is forced through a proper sized metal die in a continuous bar. As the bar moves forward, it is cut into brick by wires or an automatic machine. Dry clay is used in a machine that forces it into molds by means of plungers. These molds are in a large plate and, when filled and pressed solid, they are pushed out by another plunger.

233. **Drying.**—It is necessary to dry brick and tile before they are burned. Hand molded brick in small plants are dried on the ground with a level surface by placing them face up until the top surface is dry. The edges are then exposed for the same purpose after which they are placed on dry racks in sheds. After a short time they are placed in the kiln for burning.

Machine-made brick and tile are taken from the machine, placed on racks in a drying car which when loaded is run into heated dryers. They remain there until dry enough to burn, which ordinarily requires about one day.

234. **Burning and Cooling.**—After the brick have dried, it is necessary to finish them for service by burning and cooling.

In modern plants, the burning is done in a kiln by three methods: the down-draft, the up-draft and the tunnel kiln. The brick are stacked in the kiln so the heat can pass between them and reach all surfaces. Single down-draft kilns allow the heat to enter only at the top of the kiln and move down. In the up-draft kilns, the heat passes under and up through the brick. In these types of kilns, the heat throughout the kiln is not uniform. A combination up-and-down-draft kiln, which causes the heat to pass both up and down, gives a better result. The continuous tunnel kiln consists of two tunnels which are parallel. The brick are stacked so as to allow the hot gases which enter at the top to circulate freely and reach all sections of the kilns. Brick and tile must be cooled slowly in the kiln by stopping the fires and prohibiting the cool air currents from entering the kiln. Cooling takes a number of days, and this slow cooling anneals the brick.

MARBLE AND STONE WORKING

235. Marble and stone working involves cutting, shaping, dressing and carving stone for use, from the unfinished stone of the quarry. Artificial stones are not considered under this heading. The tools used include both hand and power tools, but hand tools are almost invariably used for the finer work.

236. **Cutting and Shaping.**—When stones come from the quarry, it is necessary to cut and shape them into sizes and shapes desired for the builder's use. The stones should be roughly shaped by breaking and knocking off the irregularities with the double-faced hammer. They can be roughly dressed with the cutting end of the face hammer. Various other hammers are used to shape and break different kinds of stone. Cutting stone into smaller pieces and various

shapes may be done rapidly with power saws and cutters. Power saws are aided in cutting by the use of sand and water run into the cut.

237. **Dressing and Finishing.**—Although the rough dressing can be done with the edge and tooth hammer and ax, chisels can be used to greater advantage. For dressing hard stone, the point-toothed chisel should be used, while the blunt drove chisel can be used on softer stone. The machine planer and cutter can be used to do stone dressing rapidly.

Stones are finished with many styles of faces, but only two methods are used to prepare the edges around the face.

Rock faced work has either pitched edges or a dressed margin. **Pitched edges** means that the edges around the face are clearly defined with a chisel line, as shown in Fig. 238. A **dressed margin** is shown in Fig. 239. However, the latter method is very little used now, since the face of the stone is usually finished the same all over. Pointed work, which is done with a pointing chisel, consists in removing the large projections until the surface is level. Tool dressing consists in using a tooth chisel to make a surface of lines across the stone. Drove work is similar to tooled work but is done with a drove chisel or drove machine. Brush hammered work is a surface full of points and is made by pounding the surface with a brush hammer. Polished surfaces, which are used in monument work, are made after the stone has been cut, planed and ground. The stone is placed on a revolving table, above which is an adjustable metal plate, which touches the stone, but does not revolve.

Fig. 238.

Fig. 239.

Sand and water are then fed between the stone and plate. As the stone revolves, the plate is pushed down until the desired polish is obtained.

238. **Carving.**—Where letters and other decorations are required in stone work, it is necessary to employ a skilled craftsman who is both an artist and sculptor. Carving may be done in the shop or after the stone is placed in the building. Lettering is usually laid out directly on the stone, but in relief work it is well first to construct a temporary model from which to reproduce the finished work. See Fig. 240.

Fig. 240.

POTTERY

239. Mixing and Preparing Clay.—Potter's and pipe clay are used extensively in making pottery. Clay is prepared for the potter's use by grinding in a dry or wet condition after it has been screened and washed to remove all foreign materials. Clay should be weathered for several months before using. Soaking, like weathering, is a natural process to bring clay to a soft form.

To make it plastic enough to use, it should be mixed with water and worked or kneaded to the proper form.

240. Forming.—For making vessels of circular form, the potter's wheel is used. It has a revolving disk upon which is placed a lump of clay. As the disk and clay revolve, the potter thrusts his thumbs into the lump and forms the inside hollow by pressure, as the clay rises between the thumb and fingers. The required thickness is obtained by gentle pressure with the fingers. See Fig. 241. Using a piece of horn or similar material, the inside is smoothed and then cleaned by pressing a wet sponge against the surface. The outside may be trued and smoothed with a strip of leather as the vessel revolves. When formed, it is removed from the disk by cutting it loose with a wire and is then placed aside to dry.

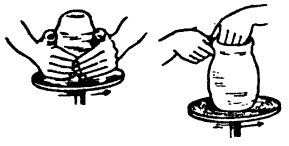


Fig. 241.

241. Molding and Casting.—**Molding** is done with a mold on a revolving machine called a jigger. The clay should first be smoothed carefully on the inside surface of the mold. As the mold revolves, the jolly which holds the pattern is brought down and the pattern held firmly within the mold, thus forming the vase or dish. See Fig. 242. Jugs and bottles can be molded in two parts and cemented together. Very fine ware can be made by **casting.** A plaster of Paris mold is first designed and constructed, as desired. See Fig. 243. The mold is then filled with liquid clay and allowed to

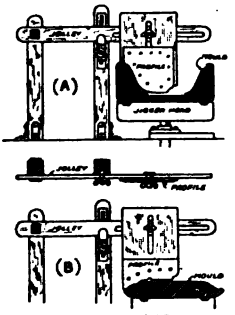


Fig. 242.

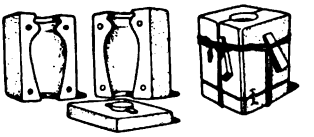


Fig. 243.

stand until a thin shell of clay is deposited around the surface of the mold. The rest of the clay is then poured out. The thin shell dries and shrinks away from the mold and can then be removed.

242. **Firing and Glazing.**—After the pottery is formed, it is allowed to dry naturally or is placed in a drying stove. The glaze and perhaps the painting and gilding should then be done. The glaze is first prepared and the articles dipped, which insures an even coating. It is very important to keep the glaze from forming in drops on the surface.

The firing which bakes the glaze into a transparent gloss finish is done in a kiln in which the temperature can be gradually increased and kept up for about twelve hours. It is then allowed to cool slowly and the articles afterward taken out.

BOOK-BINDING

243. The term, book-binding, empraces all processes by which the printed sheet of paper is made into the numerous forms of reading matter from a plain, folded circular to the elaborately bound souvenir book.

The simplest form is the folded circular made up of four pages or two leaves, being a sheet of paper creased or folded once, and usually referred to as a leaflet, four page circular or tract.

The next higher form of binding is a collection of folded papers fastened together through the folded edge or through the side near that edge. This style is known as "pamphlet without cover." The fastening is usually done by means of thread or wire. Political campaign speeches and government bulletins are examples of this form of binding.

The next step in binding is the making of a "pamphlet with cover," the cover being pasted or glued on the sheets, either after they have been folded and fastened together, or at the same time. Catalogues, price lists and telephone directories are usually bound in this way.

The basis of a bound book is the collection of sheets fastened or bound together and to which a cover is attached. In covering the book, various materials are used, such as heavy paper, cloth, leather, etc.

Replacing the heavy paper cover of a pamphlet with stiff binder's board, covered with plain or fancy colored paper, makes what is known as the stiff board binding. Some school books are bound with stiff binder's board.

When the stiff sides are fully covered with cloth, it is called the full cloth binding, the common types of which are the popular books of fiction and most school books. The books used in the higher grades in school work are usually full cloth, and sometimes, to make the book wear better, the edges or corners are covered with leather, making what is known as cloth binding with leather corners. A still stronger book is made by adding leather to the back, which style is then referred to as leather back and corners, cloth sides, or half-cloth binding.

Some books are completely bound in leather instead of cloth, but experience has proved that some of the binding cloths, known as art canvas or buckram, are more durable than leather. Many public libraries are now re-binding their full leather-bound books in cloth or art canvas. Law books, which were formerly bound in leather, are now bound in law buckram, because it is far superior to sheep leather in lasting qualities. Leather rots in a few years, while the buckram shows practically no wear after being used a half dozen years.

244. **Styles of Finish.**—The kind of finish was not mentioned above. This is really what makes a book attractive from a commercial point of view. It is usually necessary to place the name of the book and name of the author on the outside of the book, either on the back or side, or both, in plain black or colored ink, or stamped in gold.

Between the plain black title on a pamphlet cover and the gold title with ornaments on the full bound leather book, there are a great many kinds and styles of finish.

245. **Commercial Binding.**—All the processes in book-binding were originally performed by hand, and the finest bound books are still made in that way. However, the commercial book, as put on the market, involves very little hand work, as operations of folding, trimming, stitching, sewing and covering are each performed by distinct pieces of machinery. Even so simple a matter as thinning or paring the edge of the leather (so as to avoid bumps and make a neat, smooth appearing cover) is done in large binderies by means of a machine.

246. **Folding.**—The binding of a book begins with folding the printed sheet, the pages of the book having been printed on the sheet in their proper order for folding. The number of pages on a sheet depend on the size of the book and the size of the paper in its origi-

nal sheet form. The usual number of pages is eight, twelve, sixteen, twenty-four or thirty-two. A sheet of sixteen pages is folded three times and is composed of eight leaves. Each folded sheet is called a section. Folding is done by machines which may be "set" for size, number and direction of folds.

247. Gathering.—The next step is to take the sections of folded sheets and assemble or gather them in their proper order. Pamphlets or books with few pages may be gathered by hand, but, where many pages are to be assembled, gathering machines are used. The sections are then ready for stitching or sewing.

248. Stitching or Sewing.—In the regular commercial book, this operation is usually done on a machine and consists of fastening the sections together by means of wire or thread. The better class of books are sewed with thread in a manner so as to permit the leaves of the book to open to the folded edge or back.

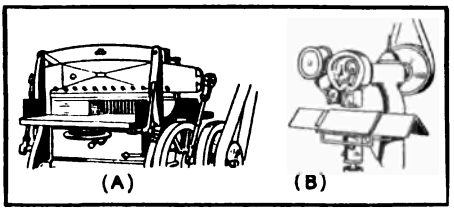


Fig. 244.—(A) Trimming machine; (B) wire stitching machine.

249. Trimming.—The sewed sections are now trimmed in a machine and the back of the book glued and otherwise reinforced for strength.

250. Covering.—The last operation in binding is, of course, fitting a cover to the sewed section, and ranges from the simple work of putting on a stiff paper cover to the elaborate and fancy work of binding a "de-lux" volume. In ordinary commercial binding, such as full cloth, the cover is put together on a machine and the sewed sections are then inserted by hand.

Since the details of binding operations are varied and often very intricate, a trip through a bindery is the best way to gain a full conception of operations used.

SECTION FIVE

DRAWING

by

GEORGE M. BRACE,
Director of Industrial Work
for Grade and High Schools,
St. Paul, Minn.

DRAWING

1. Drawing is the act of representing the appearance of objects on a plain surface by means of lines and shades. Drawing is a "universal language," common to all nations and peoples. It was the only method the ancients had of recording ideas, and drawing, or picture writing, is known to have been used by the Egyptians as early as thirty thousand years ago. They recorded much of their history and discoveries in drawings and tombs. See Fig. 1.

Fig. 1.—Egyptian heiroglyphics.

Seven thousand years ago, in the southwestern part of the United States, there lived a people whose language was expressed only by pictures, and pottery made by them shows many beautiful designs. The ancient peoples of South America have left many specimens of their art in designs on clothing and pottery. The mound-builders, an early people living in the Mississippi river valley, left specimens of their drawings and designs on pottery. See Fig. 2. The American Indian covered his buffalo robe and other skins with designs done in colors and many of these designs were stories of famous battles and exploits of bravery and skill. The Alaskan Indians still construct totem poles covered with carved drawings which represent family crests or symbols. See Fig. 4.

Fig. 2.—The Cincinnati tablet, made by mound-builders.

Civilized people of to-day would feel lost if they were suddenly deprived of art as represented in pictures, paintings and sculpture. Much of this art represents something more than mere beauty in design and color. It expresses ideas.

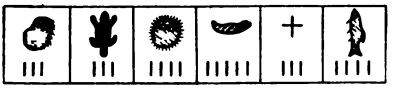
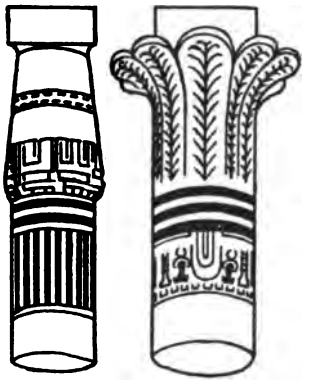


Fig. 3.—An American Indian census record.

Fig. 4—Totem pole.

So drawing has been associated with the human race from earliest times. At first,

it was the only means of recording ideas, deeds and inventions. This method of expression was very slow and only simple ideas could be presented. Thus, to show that the king had one hundred servants, required a picture of the king and his hundred servants. As people became skilled in reading pictures, parts were omitted. To the people who were acquainted with the events, the partially completed pictures served as emblems to recall the facts. Thus the wampum belts of the Indians contained a few crude symbols which recalled to the minds of the tribe entire treaties made with other tribes. Gradually the symbols were better developed, until, instead of pictures, emblems were used almost entirely. Thus, the olive branch, the dove and the pipe came to represent peace; the arrow represented war, etc. In time, symbols representing objects became entirely different in appearance from the objects themselves. The symbols then came to represent sounds, and alphabets were formed, the symbols becoming sound pictures. In Egypt this change from pictures of objects to sound pictures, which recalled the objects, had occurred possibly by 3500 B. C. Thus from drawing came a written language. See Fig. 8. The letters on this page are a form of drawing. They are more easily made than pictures of objects and serve the same purpose.



A. B.

Fig. 5.—A. Capital from Thebes—papyrus bud. B. Capital from Edfer—palm tree.

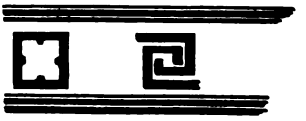


Fig. 6.—Greek pottery ornaments.

Picture drawing itself was gradually improved and is now used to express ideas in various ways. Drawings may be classed under two general divisions, free hand and mechanical drawings. Free hand drawings are those made without the use of mechanical devices, while mechanical drawings are made with the aid of rulers, compasses and other devices to insure accuracy. Free hand drawings show how an object appears to the eye and have become so highly developed that they are divided into several branches, as crayon work, pen work, oil painting, water color, etc.

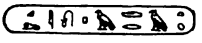


Fig. 7.—The name of an Egyptian queen in picture writing.

Mechanical drawings show the actual size and shape of an object and details of its construction. This division of drawing has been

Fig. 8.—Showing the development of the letter L.

developed and subdivided into branches, as architectural drawing, machine drawing, topographical drawing, geometrical drawing, etc. These subdivisions are closely related, but differ in certain details. Even the branches of mechanical drawing are further divided. Thus, under architectural drafting the drawing used to show electrical wiring, plumbing, etc., each has its special conventions, or methods of expression.

Different kinds and the trade uses of various branches of drawing are discussed here. No course of exercises is especially laid out, but the use of drawing in its various modifications in the trades is presented. It should lead to an intelligent understanding of drawing, which is the language of the tradesman and a means of expressing ideas in the industries.

FREE HAND DRAWING

2. Free hand drawing includes work with pencil, pen, charcoal, crayon and brush. The first four mediums of drawing produce work termed **line drawings.** The first drawing a child does occurs through the medium of pencil drawings. The highest development of all drawing is classed as oil painting. The divisions of free hand drawing are not entirely distinct from the various branches of mechanical work and their uses in all kinds of drawing make it necessary to discuss each class.

3. **Free Hand Drawing** is the oldest type of drawing. It is the simplest drawing and has been developed to the most complex. It is the foundation for all other branches of drawing and is used in every industry. The dress must be drawn before it can be made; the patterns on cloth first must be designed on paper; jewelry must be designed before it is made; pictures, casts and statues are all the handiwork of artists. Free hand drawing is the trade of the cartoonist, the furniture designer, the wall paper and carpet designer, the designer of table linens and bed spreads, draperies and curtains, laces and brocades. The most important differences between the divisions of free hand drawing are the materials used and the methods employed in using them. The idea must be developed in a similar manner, no difference by what method it is presented.

4. Pencil Sketching.—Pencil sketching is the most common form of free hand drawing and more used than all other forms, either free hand or mechanical. It is used even when the finished drawing is to be prepared by another method. Furniture designs and fixtures are first sketched free hand in pencil. Even the oil painting grows out of numerous pencil sketches. Illustrations for books and magazines, and cartoons for papers are mere pencil sketches at the beginning. Fig. 59 shows a pencil sketch of a bracket made by a machine designer. From this design a working drawing can be made, and from the working drawing the mechanic can construct the object. Fig. 9 shows a wall paper design made by an artist, which may be used in colors, if desired. Fig. 10 shows a pencil sketch of a spark plug. It may be composed with other mediums of drawing, as discussed later. Fig. 11 shows a pencil sketch of a piece of jewelry designed by an artist. Fig. 12 shows a designer's pencil sketch of a table leg to be used in making furniture to match certain other interior decorations and trim.

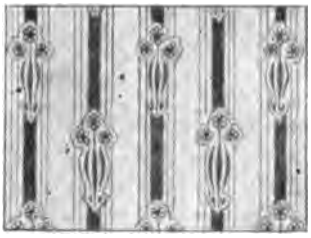


Fig. 9.

Fig. 10.

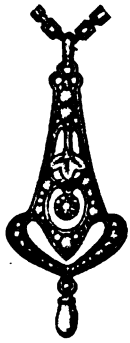


Fig. 11.

Fig. 12.

Pencil sketching requires, above all things, constant practice to develop skill. In pencil sketching, it is first necessary to learn how to hold the pencil and make the stroke correctly.

Fig. 13 shows how to hold the pencil and make the stroke in sketching a straight, horizontal line.. The arrow indicates that the line is to be drawn from left to right. The entire line is not drawn with one stroke of the pencil, but by making short strokes in the same direction. A full arm motion is used, the arm hinging at the elbow.

Fig. 14 shows how to hold the pencil and make the stroke in sketching a straight, vertical line. The strokes are made downward, using a short finger motion instead of the arm motion.

Fig. 15 and Fig. 16 show the strokes used in drawing left and right hand curves, using a short stroke as before. The left hand curve, Fig. 15, is drawn with full arm motion, while the right hand curve, Fig. 16, is drawn with the finger motion.

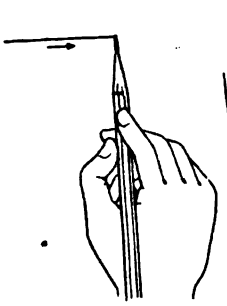


Fig. 13.

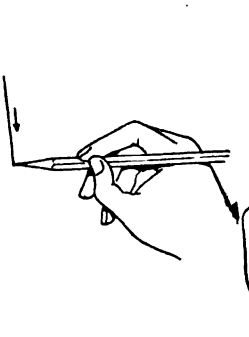


Fig. 14.

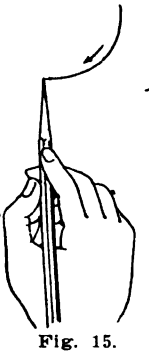


Fig. 15.

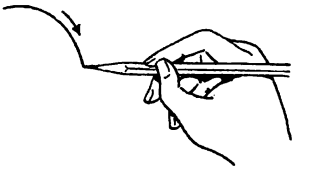


Fig. 16.

For practice, simple objects should be sketched.

Free hand sketching is valuable not only in art work, but in the shop, where one frequently has to sketch a part of a machine or a piece of furniture, and from the sketch make a working drawing.

5. **Charcoal Work.**—To make a picture appear real requires skill in rendering, no difference what medium is used. Charcoal and crayon mediums are similar to the lead pencil, but a more realistic effect may be obtained with them. In working with charcoal, after the outline has been "blocked in," color values may be rendered. Charcoal is one of the best mediums of expression we possess, as it will give all the form, light and shade one may desire and is inexpensive. Skill is necessary in handling charcoal and a great deal can be learned by studying and reproducing charcoal drawings.

Fig. 17.

Charcoal for drawing is usually made by charring willow sticks which are soft and even grained. A piece of chamois is used to rub and blend the charcoal strokes and give smooth, even tone values.

Charcoal drawings are easily reproduced for pictorial work and for advertising purposes. Fig. 17 shows a reproduced charcoal drawing of a spark plug. Commercially, charcoal is used for the preliminary blocking-in of drawings and paintings, especially those of large size. Also, reproductions may be made directly from charcoal drawings. Pictorial work in advertising matter and in fiction is quite widely represented in charcoal. The deep shades

and tones obtainable with charcoal give almost photographic clearness to charcoal drawings. See Fig. 18.

Fig. 18.—Book illustration in charcoal rendering.

6. **Crayon Work** is quite similar to charcoal. Its tones are blacker and richer and it reproduces well. Fig. 19 shows a crayon reproduction. An illustrative cartoon in crayon is of much higher grade than the average pen and ink drawing. Crayon may be used in connection with charcoal. Also, effective work in colors may be produced with colored crayons. In practical work, the chief advantage of using crayon is that the drawing may be made upon rough paper and reproduced chiefly by the zinc-etching process. Commercially, charcoal and crayon are similarly employed.

Fig. 19.

7. **Pen and Ink Sketching.**—The problems in pen and ink work are mostly the same as in pencil and charcoal rendering. However, pen and ink work is subject to more limitations than any other kind of drawing. The prominent features must be portrayed and the rest left to the imagination. The sketches reproduced here were first made with a pencil and then inked in. Shades and shadows are shown by heavy ink lines. In the sketch, Fig. 20, note that the outlines are shown by breaking the lines, rather than by making outlines, which would appear hard and stiff.

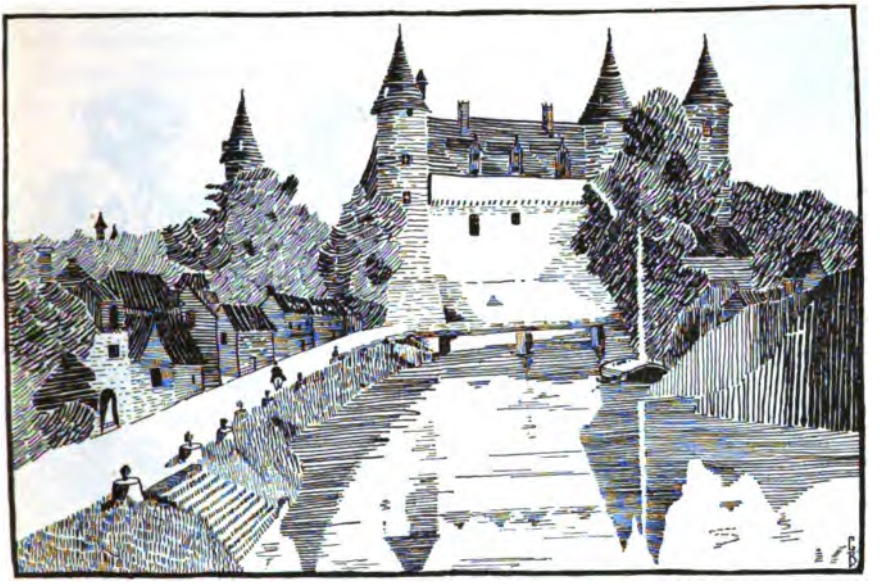


Fig. 20.

In articles as the spark plug shown in Fig. 21, the precise character of the outline makes lines advisable. Pen and ink sketching requires more practice than any other form of sketching, as the lines when once drawn cannot be easily removed or altered. If it is necessary to draw long lines, they may be broken or a few waves put in them. After learning to make the right kind of lines, making the proper combination of lines must be understood, for even good lines, unless properly combined, will not make a good drawing.

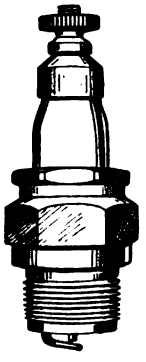


Fig. 21.

By J. N. Darling.

Fig. 22—Reduced newspaper cartoon.

Lines drawn very light with small spaces between produce a grey tint. Heavy lines drawn close together give a black effect, while paper gives a white effect. It is a safe rule to have in every picture black, grey and white. The best preparation for pen and ink work is the study of good etchings. Reproductions in books, magazines, etc., show the wide spread use of pen and ink originals. There is much variation in the style of different illustrators. Newspapers, magazines, books and catalogues show a wide use of reproductions from pen and ink drawings. The character of pen and ink drawings varies with the artist and the kind of illustration drawn. Mechanical drawings are executed in pen and ink, but, of course, are not classed under free hand drawings.

Fig. 23.—Reduced pen and ink book illustration.

8. **Water Color.**—Color painting is the highest and most difficult form of drawing. The proper use of the brush and the proper mixing of colors, to say nothing of the ability to distinguish the great variety of shades and blendings in nature, make color work extremely difficult. However, color work may be simplified so the beginner can obtain considerable drill and technic from the use of the brush.

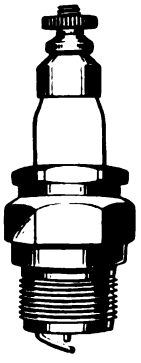


Fig. 24.

The illustration, Fig. 24, shows plain black and white work. This work can be done on white paper with the ordinary India ink, blocking in the shades and shadows with more or less definite edges. Later these edges may be softened or blended so as to produce more life-like results.

When a drawing is made of brush strokes or lines running together while wet, the process is known as "wash drawing." Such a drawing is shown in Fig. 25. Notice the smoothness of the values as compared with line work.

Wash drawings are used widely in fiction illustrations. Water color rendering proper is a step advanced over wash drawings, as the color element becomes more complex. To succeed in commercial art work to-day demands skill in the handling of water colors. Books, magazines, advertisements, etc., are made in color or with colored illustrations, and water color is one of the most convenient mediums for the original work. Probably the most widely known use of water color is in the original drawings of cover designs for books and magazines. In short, every branch of art work demands of the successful worker some knowledge of color values.

Fig. 25.

Fig. 26.—Reduced water color book illustration which was done in colors.

Fig. 27.

9. Oil Colors. — Oil work, being the most difficult of all drawing, is too advanced for the average school student to undertake, except in the most elementary way. Its method of handling differs materially from transparent water color. The illustration shown here, Fig. 27, is reproduced from a photograph of an oil paint-

ing. Oil painting, commercially, consists of the painting of pictures, portraits, ceiling and fresco work. The painting of pictures in oil formerly was not considered of importance from a commercial standpoint, but of late colored illustrations in books, magazines, etc., made from originals in oil, are common. Such drawings make elaborate cover designs and illustrations and have a very smooth, pleasing quality. Elaborate wall decoration in oil was done in Europe during the Renaissance, in churches, cathedrals and public buildings, and is now being imitated in our large libraries, capitol buildings, hotels, and other public buildings.

Drawings are also made mechanically as shown in Fig. 28. Mechanical drawings are treated in the following pages.

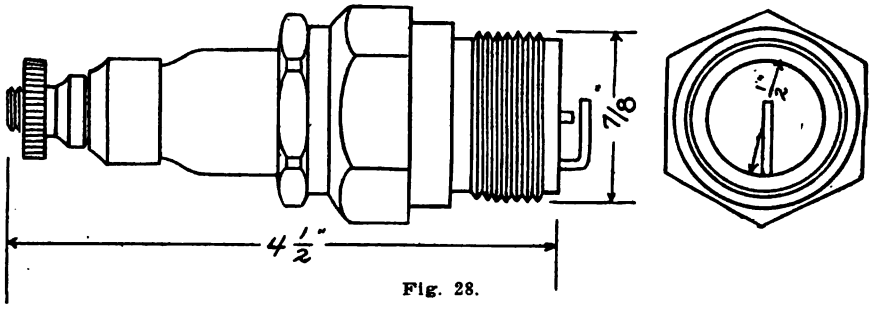


Fig. 28.

MECHANICAL DRAWING

10. All drawings accomplished with the aid of mechanical devices, as rulers and compasses, are called mechanical drawings. Mechanical drawings are based upon definite rules and conventions, the most fundamental of which are found in **geometrical construction.** In mechanical drawing, it is necessary to learn some of these fundamental rules and the draftsman's methods of making use of these rules. Only a few illustrations will be given to show what the work is like.

11. To Bisect a Straight Line.—With one end of the line **ab** in Fig. 29 as a center and any radius greater than one-half the length of the line, draw an indefinite arc. Using the same radius; but with the other end of the line **ab**, as a center, draw another arc, intersecting the first arc at **c** and **d**. Join **c** and **d** by a straight line. Line **cd** bisects line **ab** at **e**, which is the point required. In mechanical drawing, this is the common method of bisecting a line.

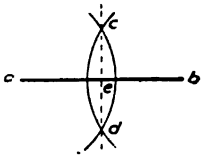


Fig. 29.

To bisect anything means to divide it into two equal parts.

The radius of a circle is the distance from the center to circumferance.

An arc is a part of the circumferance of a circle.

An indefinite arc or line is one drawn at any convenient, but no definite, length.

Intersecting means cutting or crossing; as when two lines cross, they are said to intersect.

12. To Bisect an Angle.—On the angle **abc** in Fig. 30 with **b** as a center, draw an indefinite arc, cutting the sides of the angle at **a** and **c**. With **a** and **c** as centers, and using a radius greater than half the distance between **a** and **c**, draw indefinite arcs intersecting at **d**. Connect **b** and **d** with a straight line which will bisect the angle **abc**.

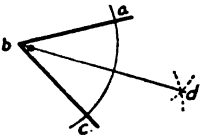


Fig. 30.

Sometimes, it is required to construct a 15 degree or 22½ degree angle. In these cases, draw with the triangles, 30 and 45 degree angles and bisect them.

13. To Construct a Hexagon.—(1) Draw a circle as in Fig. 31 and lay off the radius of the circle on the circumference six times. Connect the points where the arcs intersect the circumference, thus forming a hexagon.

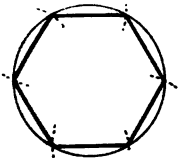


Fig. 31.

(2) When only the short diameter of a hexagon, (the distance between parallel sides) is given, erect a perpendicular **de** at the end of the diameter **ab** as in Fig. 32. Bisect the diameter, to locate **c**, and from **c** draw a line at an angle of 30 degrees to the line **ab**, and intersecting the perpendicular at **d**. With **c** as the center, and **cd** the radius, describe a circle. With **d** as a center and **cd** as a radius, describe arcs **e** and **f**. With **e** and **f** as centers, using the same radius, describe arcs at **g** and **h**; and in like manner, using either **g** or **h** as a center, describe arc **i**. Connect these six points with straight lines, thus forming the required hexagon.

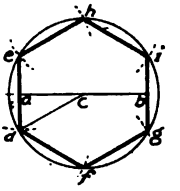


Fig. 32.

14. To Construct an Octagon.—Draw diagonals of the square **abcd** in Fig. 33. With the corners as centers, and one-half the diagonal as a radius, draw arcs intersecting the sides of the square. Connect the points of intersection with straight lines, thus forming an octagon. This method is valuable where it is desired to lay out an octagonal timber from a square timber.

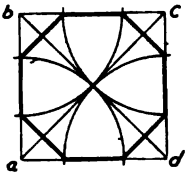


Fig. 33.

An octagon is an eight-sided figure, all sides of which are of equal length.

A diagonal of a rectangle is a straight line joining two non-adjacent angles.

15. To Divide a Given Line into any number of Equal Parts.—From one end of the given line **ab**, Fig. 34, draw another line **ac** at an acute angle to it and of indefinite length. On this line, lay off with the dividers the same number of divisions into which it is desired to divide the line **ab**. Connect the last division point **d** with point **b**, and through the other division points on **ac**, draw lines parallel to line **db**. They will divide the line **ab** into the required number of equal parts. This method is useful in dividing distances that cannot be divided readily with the rule, such as dividing a line $7\frac{1}{4}$ inches long into 4 equal parts.

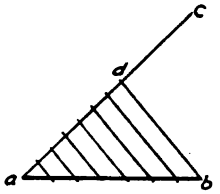


Fig. 34.

An acute angle is one less than a right angle.

To draw a line parallel with another, place the triangle on the T-square so one side of the triangle coincides with the line. Then, move the triangle along the T-square, and all the lines drawn on that edge will be parallel with the first line.

16. To Construct an Ellipse.—An ellipse is similar in appearance to a flattened circle and has a long and short diameter. See Fig. 35. To construct an ellipse, having given the two diameters, draw two circles using the same point for the centers. Make one circle with a radius one-half the short diameter of the ellipse and the other with a radius one-half the long diameter. From the center **o**, draw any number of radii, intersecting both circumferences. From the intersections of the radii with the larger circumference, draw vertical lines. From the intersections of the radii with the smaller circle,

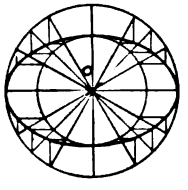


Fig. 35.

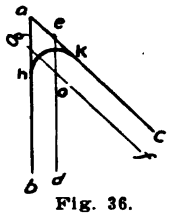


Fig. 36.

draw horizontal lines. Through the points where the vertical and horizontal lines intersect, draw the ellipse freehand.

It is necessary to make ellipses when drawing arches for buildings and bridges, openings for fireplaces, etc.

17. To Draw an Arc Connecting Two Lines Intersecting at an Angle.—In the angle **bac** in Fig. 36 draw line **de** parallel with **ab.** The same distance from **ac,** draw line **fg** parallel with **ac.** With the intersection point **o** as the center, and the distance from **de** to **ab** as a radius, draw arc **hk.**

ISOMETRIC PROJECTION

18. There are several ways of making drawings which resemble perspective or picture drawings, and one of these is called **isometric projection.** In isometric drawings, the two adjacent sides of a square make equal angles with a horizontal line.

A view of a piece showing more than one surface gives a better idea of its form and construction than a simple view. But for actual construction, "picture drawings" are not usable, as they are not made to true dimension throughout. However, isometric projection has been designed to show correctly in one view the relative positions of the surfaces of an object and also the important dimensions. Within certain limits, isometric projection may be used in place of simple working drawings in the workshop. The isometric projection does not take the place of other drawings, but in many cases is used to aid the workman in getting a clear idea of the assembled object. Machines, furniture, buildings, etc., often have an isometric projection accompaning the more detailed working drawing.

In the drawing of the Nail Box, A in Fig. 37, the line **ab** is first drawn at an angle of 30 degrees with the horizontal. This is usually done by placing a 30 degree triangle on the edge of the T-Square, and drawing a line **ab** along the 30 degree edge; then turning the triangle over and drawing the line **ac** at the same angle in the opposite direction. The lines **ad, ce** and **bf** are vertical lines. All lines that are horizontal in the object, are drawn at an angle of 30 degrees and all vertical lines in the object are drawn vertical. The advantages of this form of drawing are, that it represents the object very like a picture, and is not so difficult to draw as a perspective. It is also more accurate

because it is made with instruments and from exact measurements which cannot be used for a perspective drawing.

B in Fig 37 is an isometric projection of a pillow block, which is a box for holding or housing the axle of a machine. This figure shows how to draw a circle and other curves in isometric projection.

The lines **ab** and **ac** are laid out in the same way as in the nail box and vertical lines are erected at the three points. At the middle of the line **ab** a vertical line **de** is erected. From points **d** and **e**, 30 degree lines, **fg** and **hi**, are made, and connected with vertical lines, **fh** and **gi**. This makes an isometric square. A circle inscribed in any square touches the sides of the square at their middle points. The top of this pillow block touches the middle points **k**, **e**, and **l**. An isometric

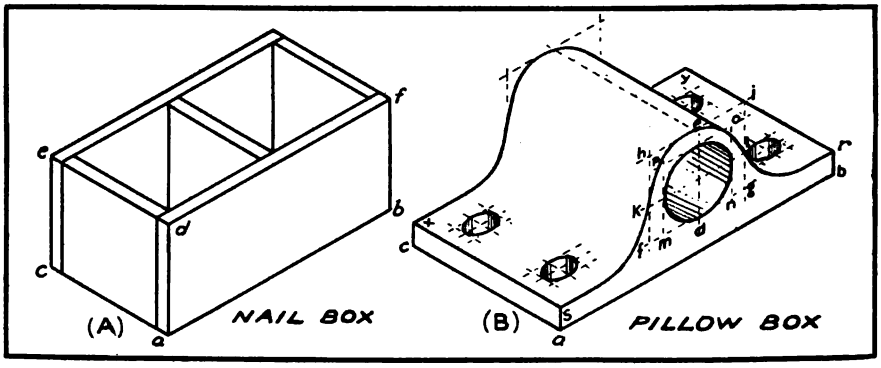


Fig. 37.

circle is elliptical in form, so this curve is one-half of an ellipse. It is connected with the vertical lines **as** and **br** by drawing curves as **ks**, either free hand or with an irregular curve.

Inside the square **fgih**, draw another square **mnop** and inscribe a complete ellipse, which will represent a circle. The other edge of the pillow block is made parallel to the front edge. The bolt holes are drawn in a similar manner. As they are elliptical in the pillow block, they will appear even more elongated in a drawing of this kind.

CABINET PROJECTION

19. Another method of representing an object as it appears to the eye is by means of **cabinet projection.** It is similar to isometric projection, except, instead of the horizontal lines of the object being drawn at an angle of 30 degrees, receding lines are drawn at an angle

of 45 degrees to the horizontal, and one-half their true length, and the others are drawn horizontal. Vertical lines are drawn vertical.

Both isometric and cabinet projection are used quite generally to show machine parts, details of assembling, methods of construction and joinery in buildings, furniture, mechanical appliances, etc. They are found in popular magazines and books which need to give a picture and essential dimensions on the same drawing.

In the Bench Hook, A in Fig. 38, one set of horizontal lines **ab, cd, ef,** etc., remains horizontal, while the other lines are drawn at an angle of 45 degrees, but one-half of their true lengths, as **cg, eh,** and **fi.** In drawing circles or curved lines in cabinet projection, it is necessary to draw squares or rectangles first as **abcd** in **B** Fig. 38, and then draw an ellipse inside the square.

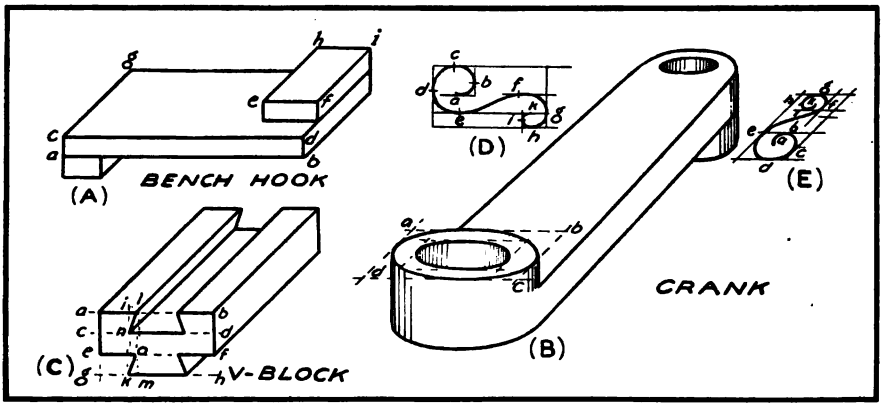


Fig. 38.

In drawing any irregular object, as a V-Block, **C** in Fig. 38, horizontal and vertical lines as **ab, ac,** etc., are drawn and points **l, n,** and **o, k,** etc., located and connected with straight lines. In drawing an irregular curve, it is well to make a sketch of the curve and then surround it with rectangles, as **D** in Fig. 38, locating the points **a, b, c,** etc., where the curve touches the rectangular sides.

Next the rectangles are drawn in cabinet projection, as **E** in Fig. 38, and the same points located. The curve is drawn touching these points. Both isometric and cabinet projection show the object to better advantage than a mechanical drawing, because they are more easily understood and one does not have to study in order to see just how an object will look when made.

However, they do not take the place of mechanical drawings, because workmen usually do not make an object without an accurate working drawing giving all the dimensions.

PERSPECTIVE

20. **Perspective drawing** is the representation of an object as it actually appears to the eye. In other words, it is a correct picture of the object.

A knowledge of perspective is necessary before sketches, commercial illustrations, cartoons, magazine and book illustrations can be made in free hand work. Commercial artists are often called upon to make a birds-eye view of some farm, factory or other site. Or, they may be required to make a perspective of a machine, an interior scene, etc. The decorator, in planning the interior of a building, has interior perspectives made up, usually with color added. The architect in drawing a building not yet erected, works out a perspective from the plans and shows the building as a photograph would do. It

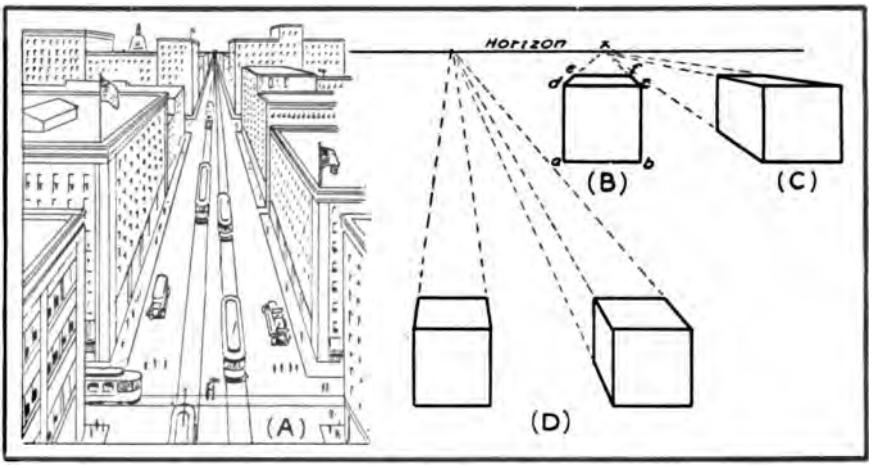


Fig. 39.

cannot be measured, and, without the plans, would be of no value from which to build. The architect makes perspective drawings chiefly to show his client what the building will look like. Some important facts and rules which must be understood before attempting to draw perspectives are:

(1) Objects of the same size appear alike in size when placed at the same distance from the observer; but, if one is placed at a greater distance than the other, then it appears smaller, and the farther away it is, the smaller it appears. See A in Fig. 39. The cars shown are all the same size, but those farthest away appear smallest because of perspective.

(2) The horizon is a line on a level with the observer's eye. Looking from different heights gives different horizons.

(3) All straight, parallel lines running away from the observer come together at a point on the horizon. In A, Fig. 39, the car lines and buildings are parallel, yet they seem to meet at a point on the horizon directly in front of the observer.

(4) All lines parallel with the horizon have no perspective. In A, Fig. 39, the car line across the drawing is parallel with the horizon and therefore the lines do not converge or come together.

A cube may be drawn in perspective as indicated by B in Fig. 39. The square **abcd** is drawn, and, from the two corners **c** and **d**, lines are drawn to a point on the horizon. The horizon may be placed as far above the object as desired. It is best to place it far enough to show the top of the object, but not so far as to make it look unnatural. B, C and D, in Fig. 39, represent cubes seen from different angles. Line **ef**, between the converging lines, is located so that **cdef** appears to be a square drawn in perspective. There are ways of locating the back lines by measurements, but they are difficult. The lines are easiest located by judgment and a few trials will enable this to be done accurately. In B, Fig. 39, two sides of a cube are visible. If the cube is placed to the right or left, as C in Fig. 39, and drawn in perspective in the same way, three sides are visible. This makes a better picture.

B, Fig. 39, shows parallel perspective, and is the simplest kind, but not the most common. It does not give as good a picture as one made at an angle. When made at an angle, the perspective is called angular perspective.

ANGULAR PERSPECTIVE

21. In parallel perspective all horizontal lines are parallel with the horizon, and all vertical lines at right angles to the horizon, and the object has one vanishing point. This arrangement of lines is undesirable in some views, especially in interiors, and another kind of perspective, called **angular perspective**, is used. In angular perspective, the object is assumed to have been turned so that the lines parallel to the horizon in parallel perspective are at an angle to the horizon. This makes an additional vanishing point.

There are a few rules to remember in this kind of perspective:

All parallel lines converge to the same point, except lines parallel

with the horizon and vertical lines. In A, Fig. 40, six squares are placed at different heights, and with their sides at angles with the horizon instead of parallel with it. In construction, a line is drawn from point a to x, and another from point a to y, then point b is located on the line ay and d on the line ax. Notice that the distance ad must be short in order to make it appear the same length as ab. From points b and d lines are drawn to x and y and they will intersect at c making a square abcd.

This drawing may be made by placing a in a different position as at a', m, n, o, p, etc. In every place the perspective will be that of the same square with the edges all converging to the same points, x and y. These points are called vanishing points. In m and n, the lines are of unequal length, because the positions of m and n make them farther from one vanishing point than from the other.

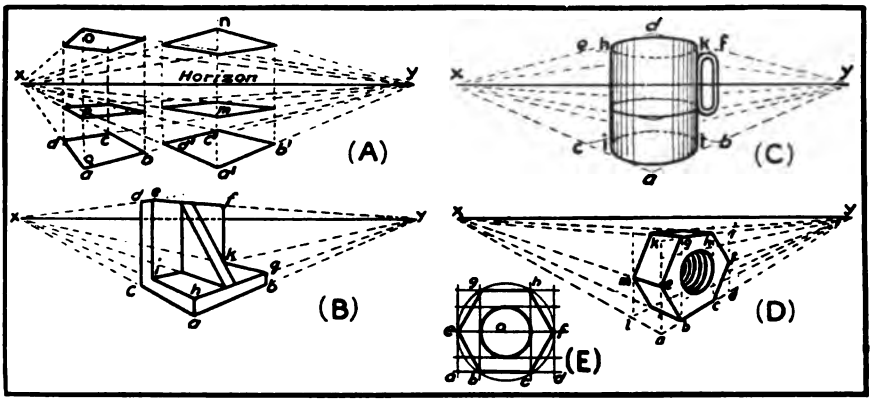


Fig. 40.

In B, Fig. 40, an iron bracket or angle block is part above the horizon and a part below. The vanishing points may be placed anywhere on the horizon, but the farther away they are placed, the more natural the picture will appear. The point a, is located below the horizon about the middle of the space, and two lines ax and ay are drawn to the two vanishing points. The points b and c are located so as to make the length and breadth appear to be in the same proportion they are in the object. The line ah represents the thickness, and from h, lines are drawn to the two vanishing points. From b a vertical is drawn, locating g on hy. Then gx is drawn. From c a perpendicular cd, represents the height of the block. A line is drawn from d to the vanishing point x and extended from d to locate point e. The line de represents the thickness, and is made to appear the same thickness as ah.

Points **e** and **y** are connected; from **e** a vertical line is dropped crossing **hx** at **i**, furnishing the line **ei**. Points **i** and **y** are connected and at intersection of **iy** with **gx**, point **k** is located. From **k** the vertical **k f** may be erected. The center of the line **hg**, is located and the brace for the bracket drawn. The completed drawing shows the bracket as it appears, but it does not show dimensions.

It could not be scaled by a workman and unless accompanied by working drawings would be of little value.

In **C**, Fig. 40, a curved surface is represented in perspective. It is easiest made by constructing rectangles, starting at points **a** and **d**, and drawing ellipses in these rectangles. Lines **hi** and **kl** connect these ellipses at their extreme points.

In **D**, Fig. 40, a hexagonal nut is shown in perspective. First a circle is drawn the size of the nut and a hexagon inscribed, as explained in Art. 13. See **E**, Fig. 40. Then the entire drawing **E**, Fig. 40, is drawn in perspective as shown at **D**. The thickness of the nut **em** is estimated and the edges on the back surface completed. An inner circle is drawn to represent the hole in the nut.

The threads are portions of ellipses each one of which is smaller than the preceeding one.

ORTHOGRAPHIC PROJECTION

22. **Orthographic projection** means projecting in straight lines. In order to understand the drawings made and used in every day life, it is necessary to understand orthographic projection, because it is an essential of all mechanical drawings.

Orthographic projection gives the views necessary to show all dimensions and the arrangement of parts in objects. Most working drawings are simple orthographic projections. This method of drawing is used alike by the carpenter, cabinet-maker, machinist and engineer. Probably it is more used than all other forms of projection combined and it furnishes the foundation for all the others. It should be well understood before proceeding with other forms of mechanical drawing.

To understand or read drawings requires the ability to see just how an object looks from the drawing, without having a picture of it.

Assume that some object, as a piece of wood, is placed in the center of a glass box so it can be seen from all sides. See **A**, Fig. 41. Looking directly down at the object in the box, the object will appear as shown by **abcdef**, marked on the top glass, and is called the top view.

Looking at the side of the object shows the side or front view, as represented by **hkcgba,** drawn on the side of the glass box. Looking through the end glass at the object, it appears as shown by **bcklde.** This is called the end view. Other views are unnecessary as they would not show anything more about the shape of the object. If the top piece of glass were lifted to a vertical position, and the end piece of glass swung out so that all three surfaces were in the same plane, the drawings would show as in **B,** Fig. 41. The relation of the three views is clearly shown.

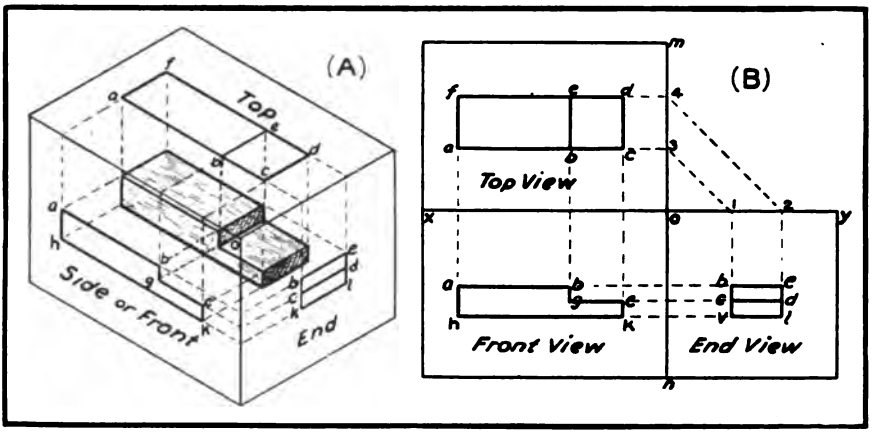


Fig. 41.

The top view is always over the front view, and the end view is at one side of the front view. The outlines of the faces of the object in the box are located on the sides of the box by projection lines as shown in **A,** Fig. 41.

A careful study of these lines will help to visualize the object from the drawings. Notice that the working drawings of the block show the relation between views.

Not all objects can be shown properly by three views. Some are so complicated that more views must be given and sometimes a section or two must be included, in order to give a clear understanding of the shape of the object. Three-view drawings of several objects that are simple in construction should be drawn before attempting the more difficult ones.

The view that gives the most information about the object should be drawn first. If this be the front view, then projecting horizontally over gives part of the end view and vertically upwards part of the

top view. From measurements, complete either the side view or the top view, and then by projection, complete the other views.

The lines **xy** and **mn**, in B, Fig. 41, show the edges of the three glass sides of the box. In order to project from the top view to the end view, it is necessary to project over on one of these planes, points as (1) and (2), the same distane from **o** as points (3) and (4).

This can be done either by measuring the distance or by using a 45 degree triangle placed on the T-square. The latter method is usually the most convenient.

ARCHITECTURAL DRAWING

23. Drawings used in connection with the layout and construction of a building are called **architectural drawings.** A set of architec-

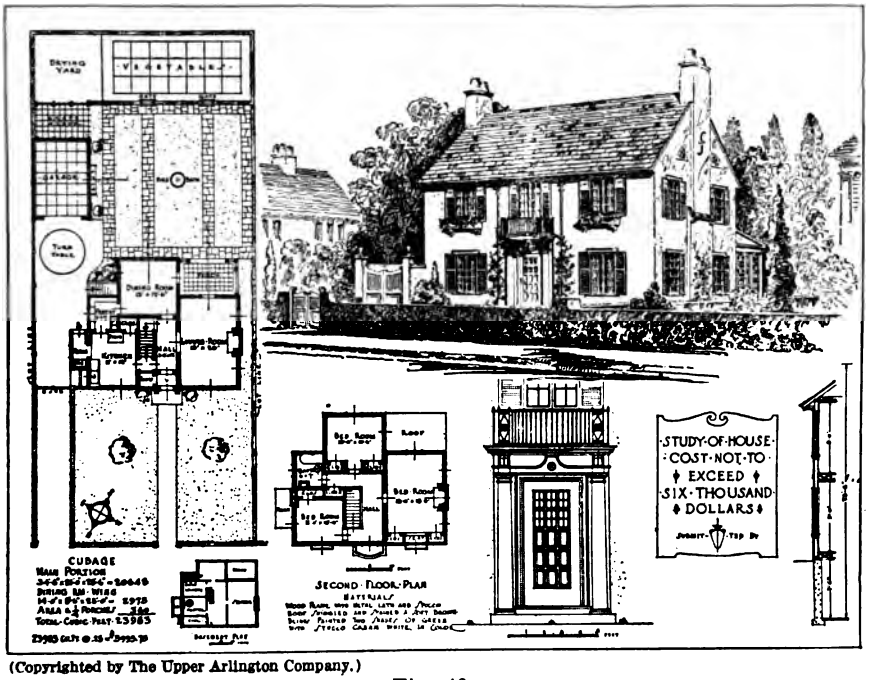


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Fig. 42.

tural drawings usually comprises plans, elevations and detail drawings. Preliminary to making the working drawings, perspective sketches are usually made to show the client the finished appearance of the building and to give a basis for making the working drawings. There may be additional drawings required, or some of the above may be omitted. For example, special heating or ventilating plans may be

omitted and included with the finished plans. There may be a number of elevations required, as front elevation, right and left side elevation, rear elevation and elevations showing cross sections. Thus an architectural drawing may vary from a simple three-view drawing to an elaborate set comprising any number of views. There are some things pertaining to the construction of a building which cannot be shown by drawings and these are included in a set of specifications. For example, the concrete mixture used in the foundation, the quality of lumber used throughout or the kind of finish can not be shown.

In designing a building, the first step is to sketch an experimental arrangement of rooms, with convenience in mind and without special regard to dimensions. See Fig. 42. Since the arrangement of the principal rooms is of primary importance, they should be given first consideration.

It is usually best to begin with the first floor plan. Following the first floor plan may come the second floor plan, etc. When the sketches are completed and the required number of rooms shown in their relative positions, a definite point towards which to work has been established and the plans may be undertaken. Probably the finished plans will not be exactly like the sketches in some details, for it is often impossible to incorporate all ideas included in the sketches in the final drawings.

A plan is made for the basement, each floor and the roof. After the plans have been made to scale, with windows, doors, chimneys, stairs, heating, plumbing and lighting layouts provided, details may be drawn showing many things which are not explained on the plans. Thus, details of a fireplace, built-in bookcases, window and door construction, interior trim, etc., each may require a separate drawing. Some of these details may be shown full size, but most of them are usually large scale drawings. In all working drawings, made less than full size, the architect makes what is known as a scale drawing. Such a drawing, besides having the essential measurements given, has the scale marked and any dimensions not given may be obtained by scaling the drawing. However, the workman should not need to scale a drawing, for all essential dimensions should be given. The illustrations shown here were reduced form working drawings which were drawn to a scale of one-fourth inch to the foot as indicated in each. A line one inch long on the working drawing represents four feet on the building.

Elevations show the appearance of a building as well as important dimensions. For a simple building, one elevation may be sufficient, but usually in house construction at least four are made. The building

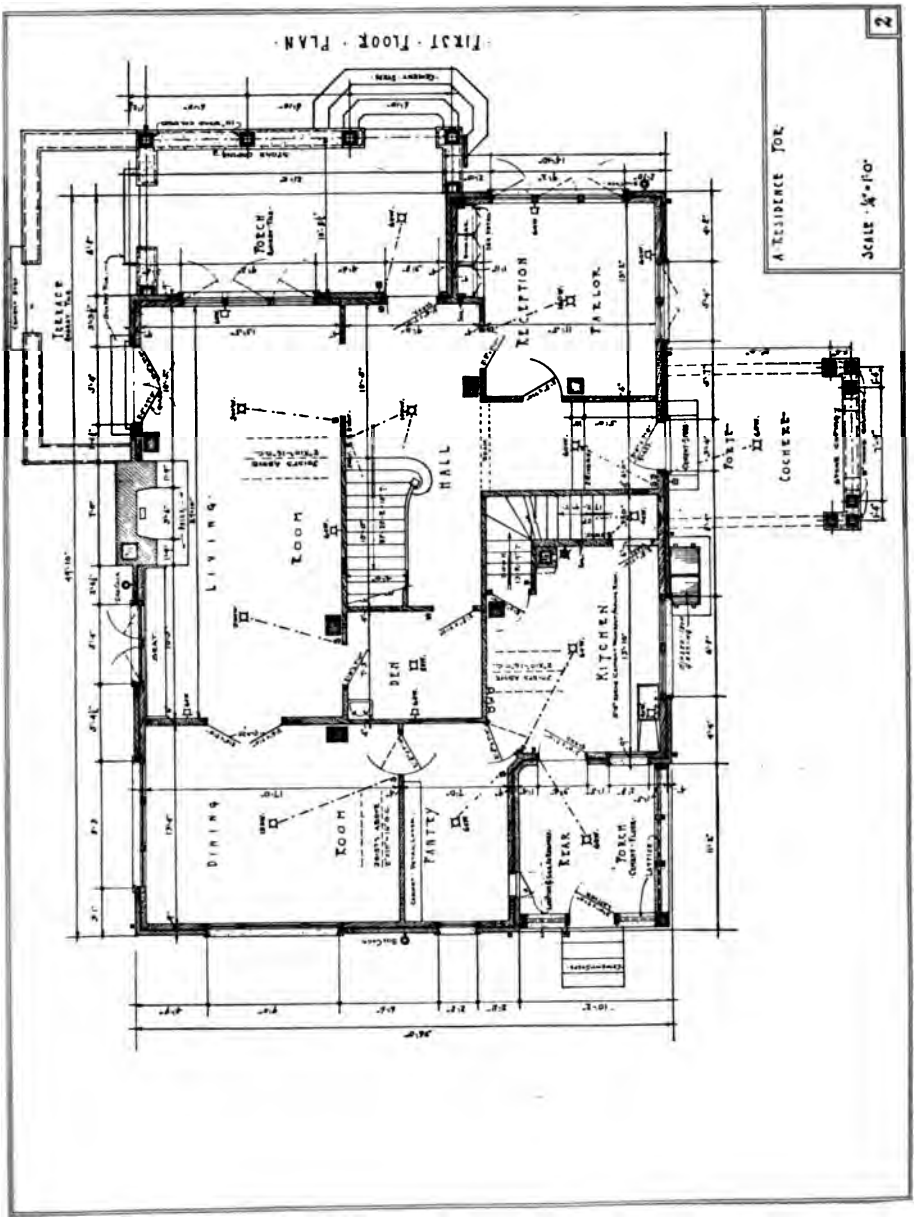
FIRST FLOOR PLAN
A RESIDENCE FOR
SCALE
2
TERRACE
PORCH
RECEPTION
TAILOR
LIVING ROOM
HALL
PORTE-COCHERE
DEN
KITCHEN
DINING ROOM
PANTRY
REAR PORCH

Fig. 43.

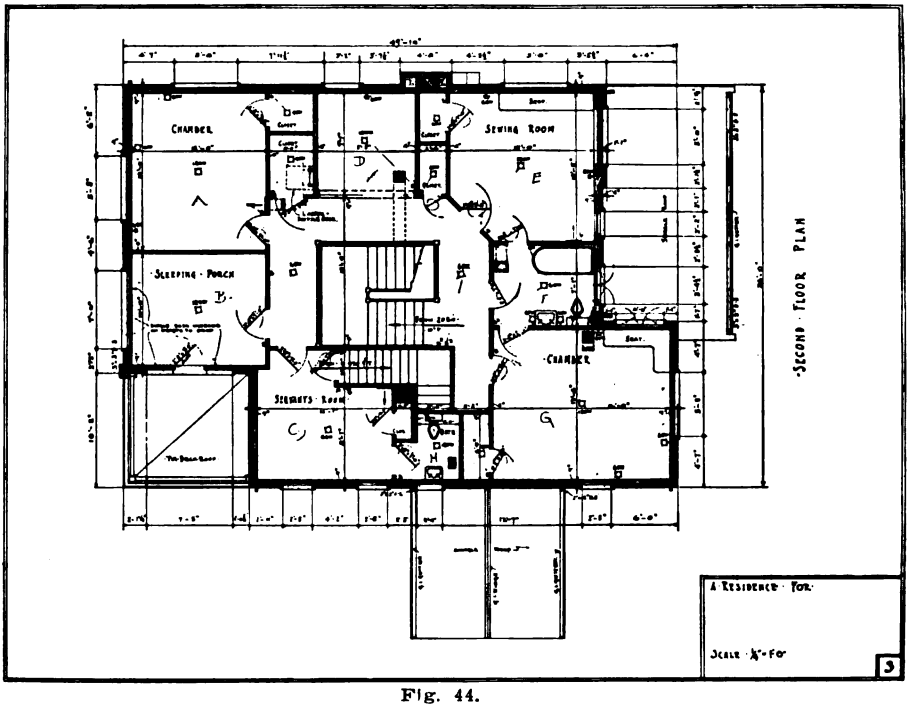
CHAMBER
SEWING ROOM
SLEEPING · PORCH
CHAMBER
SECOND · FLOOR PLAN
A RESIDENCE · FOR
3

Fig. 44.

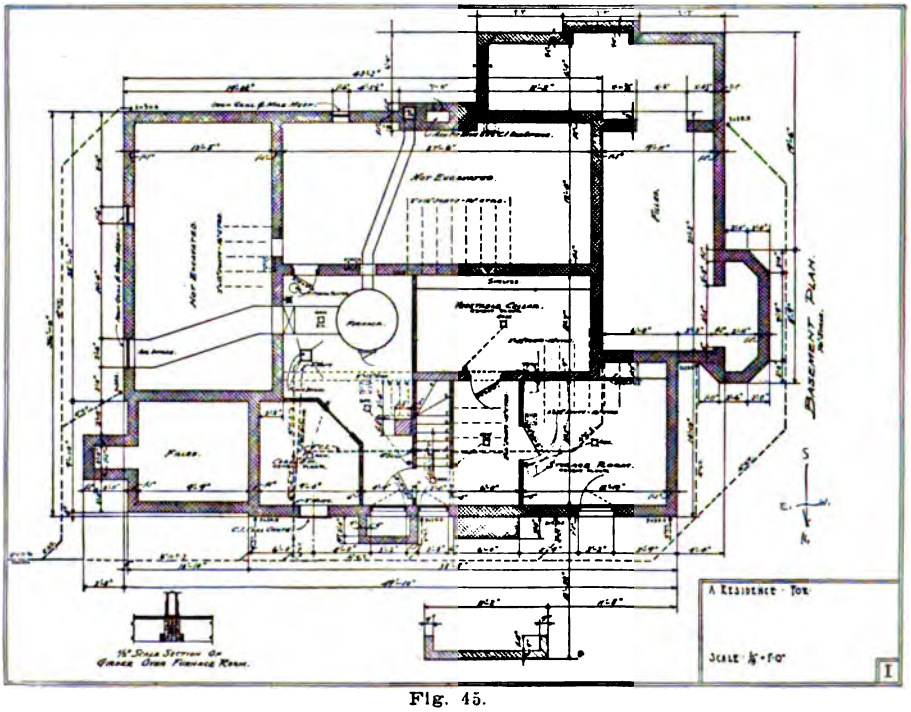
BASEMENT PLAN
A RESIDENCE · FOR
I

Fig. 45.

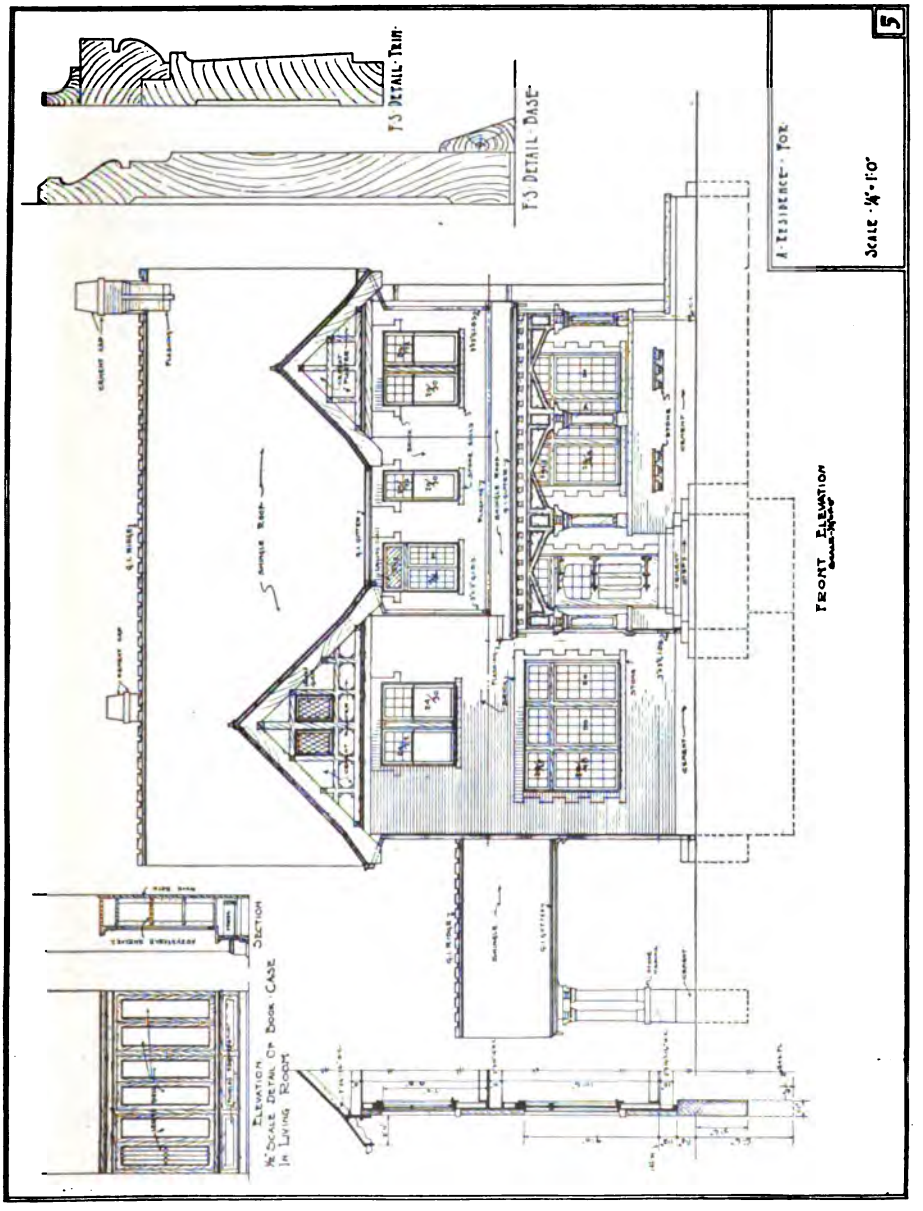
F.S. DETAIL-TRIM
F.S. DETAIL-BASE
A RESIDENCE-FOR
SCALE 1/4"=1'0"
FRONT ELEVATION
SECTION
ELEVATION
1/2" SCALE DETAIL OF BOOK-CASE
IN LIVING ROOM

Fig. 46.

drawings shown here had in the set four complete elevations besides the cross section shown among the details in Fig. 48.

24. **Conventions.**—In architectural drawing, various methods are used to represent different details of construction. In the house plans, Figs. 43, 44, 45, notice the conventions shown.

Observe in Fig. 45 that the walls are cross hatched in a manner which designates concrete construction. Note the heavy black dots at several corners, which designate the down spouts from the roof. The dotted line from each down spout is a line of drainage tile and leads to the sewer. In the furnace room is shown a floor drain with tile leading to the sewer. Observe that the stairs have thirteen nine-inch

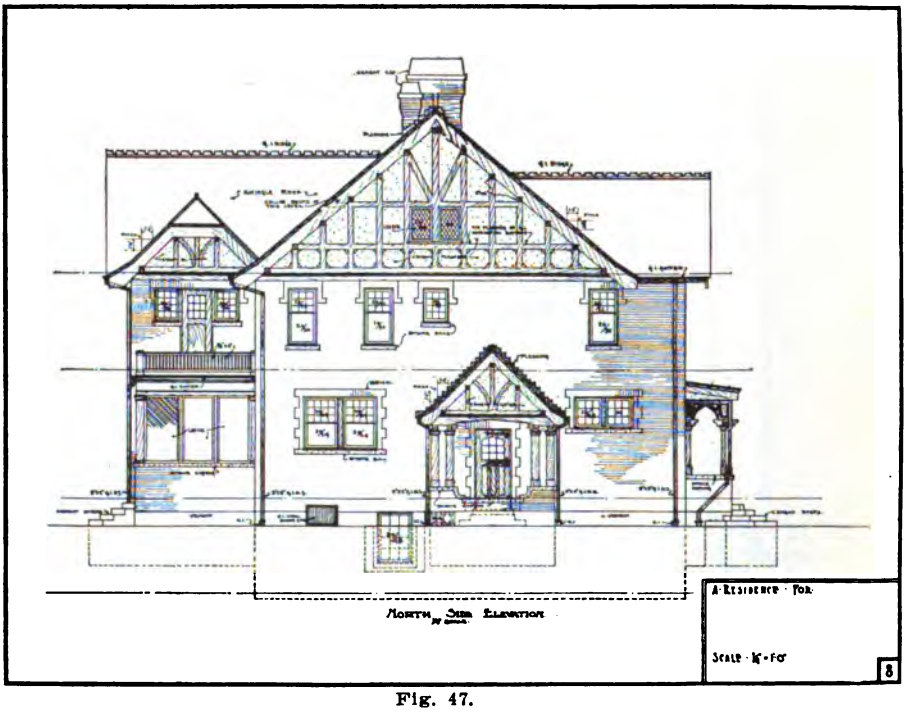

Fig. 47.

treads, with a sixty-watt light at the head of the stairs and a forty-watt light at the foot. All electric lights are designated by such conventions and the number of lights in the fixtures may be indicated along with the convention. Note how the furnace is shown with its air intake and with its smoke pipe leading to the chimney.

In Fig. 43, observe that the outside walls are made of two different kinds of material. The cross hatching shows wood surrounded by a

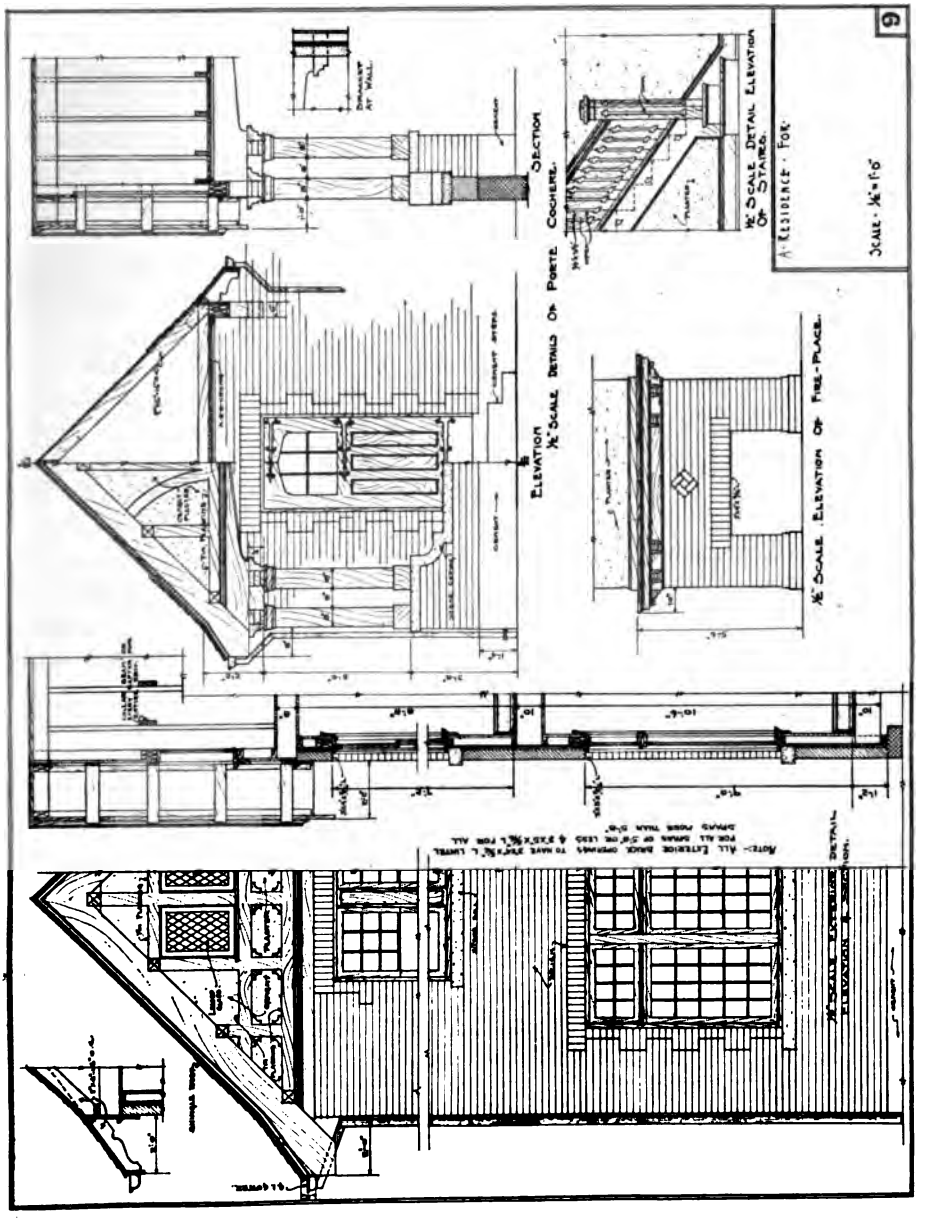
9
A-RESIDENCE-FOR
SCALE-1/4"=1'-0"
1/2" SCALE DETAIL ELEVATION OF STAIRS.
SECTION
ELEVATION
1/2" SCALE DETAILS OF PORTE COCHERE.
1/2" SCALE ELEVATION OF FIRE-PLACE.
DRAINAGE AT WALL.

Fig. 48.

layer of brick on the outside. Such a wall is called a veneered wall, The basement stairway is shown again and also the chimney leading up through the corner of the kitchen. Observe that a gas connection has been placed near the chimney in the kitchen. The convention is similar to an electric convention except that it is solid black. In the living room is shown the fireplace, and on one side of the fireplace a window seat with casement windows above and opening out. On the other side are shown double glass doors leading to the terrace.

In Fig. 48, showing details, note the cross section of elevation showing height of the rooms and building. Also observe the outside detail, fireplace detail, etc. Much of the outside detail is shown on the elevations, Fig. 46 and Fig. 47.

Aside from the manner of showing details in the plans, it is important to visualize the connection between the different floor plans. Examine Figs. 43, 44, and 45 in connection with each other. Notice how the walls coincide, as well as how the stairs, chimney, plumbing, heating, etc., are projected up from the basement through the first floor.

In a like manner, study the second floor plan figure in connection with the first floor plan. Observe how the arrangement provides for preventing chimneys going through rooms, how walls upstairs coincide with those downstairs, how plumbing is provided for and how stairs connect the two floors.

In actual work, the original drawings are made upon tracing paper or cloth and are known as original tracings. From these tracings, blueprints are made and used as needed. Construction work is never done from the original tracings.

INTERSECTIONS OR PENETRATIONS

25. **Intersections or penetrations** deal with the cutting of one or more forms by another. Intersections or penetrations are common in drawing, examples being the penetration of roofs by chimneys and

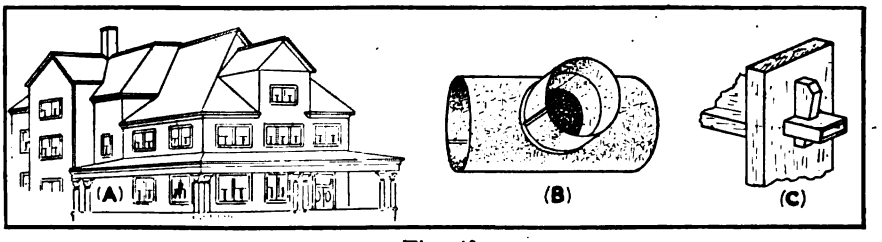

Fig. 49.

gables, the joining of pipes, tile, wood members, etc. Fig. 49 illustrates this kind of drawing. Intersections are so important that it is necessary to know the principles on which such drawings are made. In almost every working drawing where assembled parts are shown, intersections occur. Often the intersections are the only parts of a structure where difficulty is experienced in the designing or drawing. Fig. 50 is a perspective view and shows one rectangular prism passing through another.

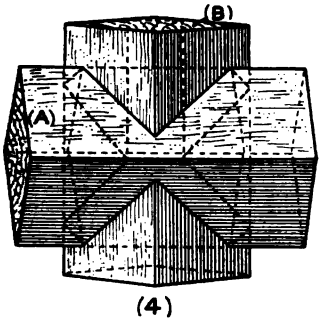

Fig. 50.

The principles involved are given in Fig. 51. The views number (1), (2) and (3) are views which make a working drawing. They are orthographic projections. A careful study of (1), (2) and (3), in connection with Fig. 50, will show where each line was obtained. Heavy dotted lines on the

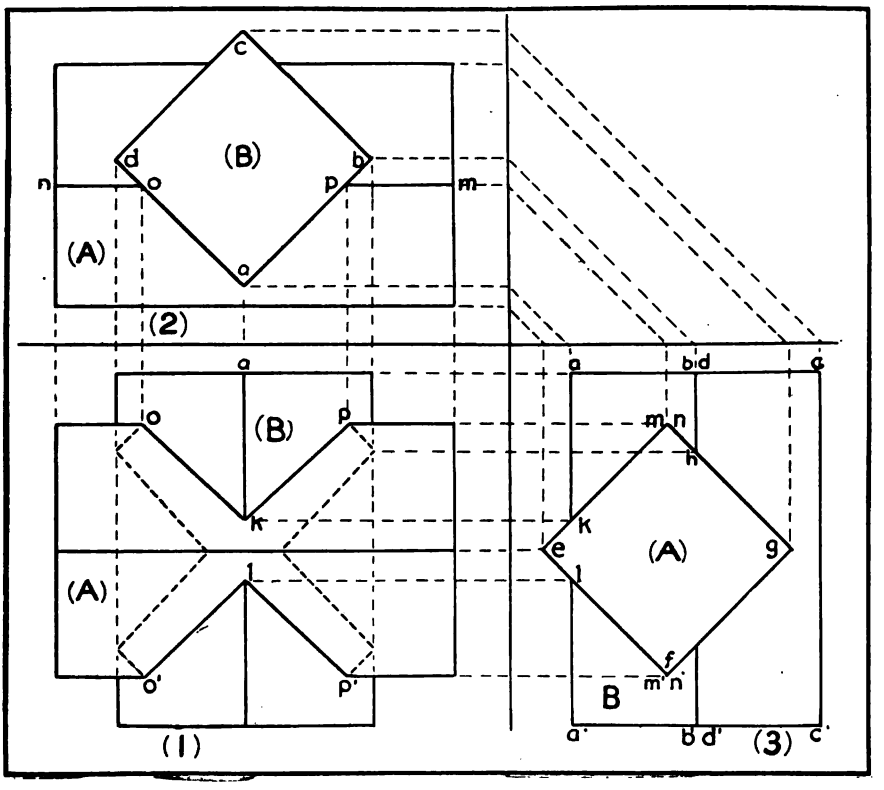

Fig. 51.

figures show hidden edges, and light dotted lines are projection lines. Number (1) is the front view and both prisms are shown. Note that prism (A) is not intersected by (B) on its front edge, but is intersected on the other three edges. In (2), which is the top view, the end of prism (B) is shown, and gives a clear idea of where (B) intersects the edges and faces of (A). In (3), which is the end view, the end of prism (A) is shown. The end view shows nothing that is not shown in (1) and (2) except the end of (A).

DEVELOPMENTS

26. **Development** of surfaces is the method by which the surfaces of objects are laid out on one plane. The surfaces may be laid out as one or more pieces, these pieces being called patterns. Patterns may be laid out directly upon the material, or upon paper, and transferred to the material. Then the material is cut out and the edges fitted together, thus forming the object. When the article to be made is simple in form, the pattern is generally laid out on the material. Usually it is desirable to to make full sized drawings of the object, and from the drawings develop the patterns on paper. After the pattern is developed, it is transferred to the work. Development of surfaces finds practical use in the sheet metal trade, as in making automobile bodies, bedsteads, feed troughs, locomotives, metal barrels and cans, boats, steel cabinets, furnace pipes, etc. Sheet metal is used in most of the industries and is rapidly gaining in importance.

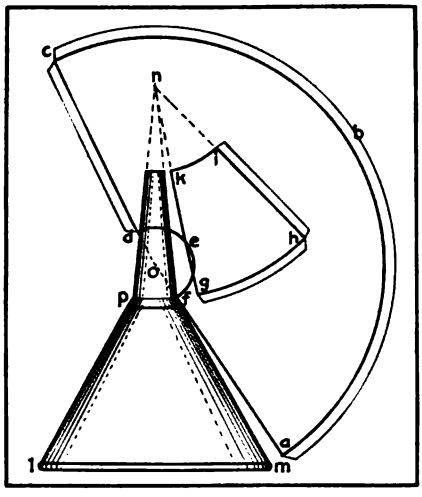

Fig. 52.

The funnel shown in Fig. 52 is made up of parts of two cones. A drawing should be made full size and the two patterns necessary developed from the drawing. The patterns shown are shaped like the funnel would be, if it were separated where the neck joins the body, the seams opened up, and the two pieces spread out flat.

The pattern is made as follows: A drawing of a side view of the funnel is made and the sides **mf** and **lp** continued to their intersection at point **o**. In the same manner the cone **pnf** is completed.

With a pair of compasses set to the distance **om**, and with **o** as a center, the arc **abc** is drawn. With the same center and the radius **of**, arc **fed** is made. Line **fa** is drawn at any convenient place. Beginning at point **a** on arc **abc**, a distance is laid off equal to the circumference of the funnel. This locates point **c**. Line **oc** completes the pattern of the body. The pattern for the neck is laid off the same way.

In a similar way any pattern may be developed.

WORKING DRAWINGS

27. All drawings used in construction work may be divided, in general, into two classes, pictorial drawings and **working drawings.** Working drawings are so complete in detail and measurements, that the object represented can be made accurately from the drawings. This is done by making orthographic projections, as previously explained, upon which all essential dimensions may be placed.

Working drawings are of two kinds, detail drawings and assembly drawings. Detailed drawings give the dimensions of the parts, while assembly drawings show by position the relationship of parts.

Architectural drawings are working drawings as they are used in building structures. Machine drawings are working drawings of

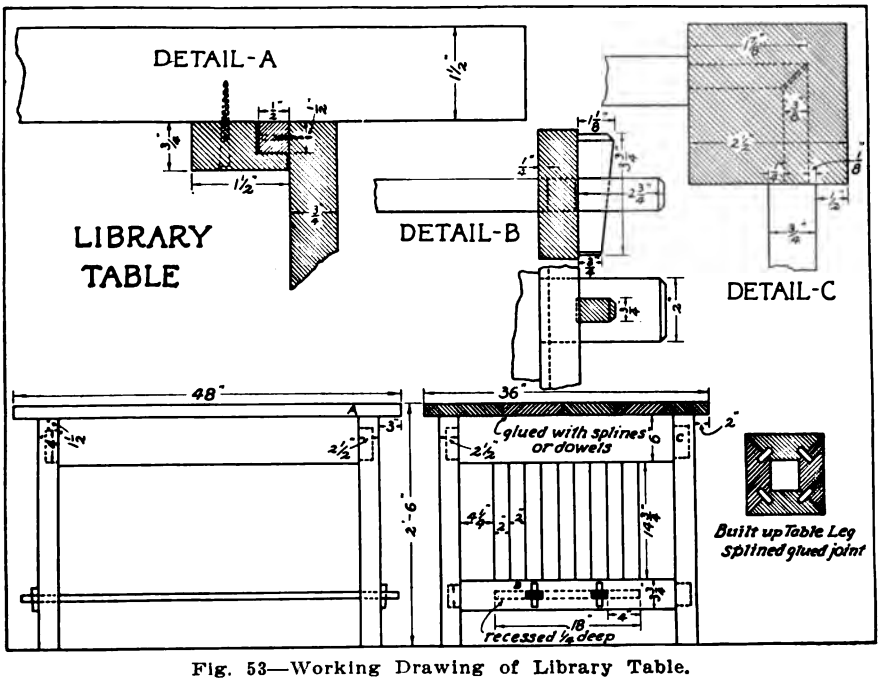

Fig. 53—Working Drawing of Library Table.

machines and machine parts. In making working drawings, at least two views are made, and generally no less than three are given. Fig. 53 shows a working drawing for furniture work and Fig. 55 shows a working drawing of machine parts. Working drawings are made to scale and the scale is usually given on the drawing.

As all essential dimensions are placed on the work, the scale may be omitted, if desired. This has been done in Fig. 53. All dimensions required for making the exhaust cut-out finger ring (Fig. 62) are given and it is unnecessary to give the scale.

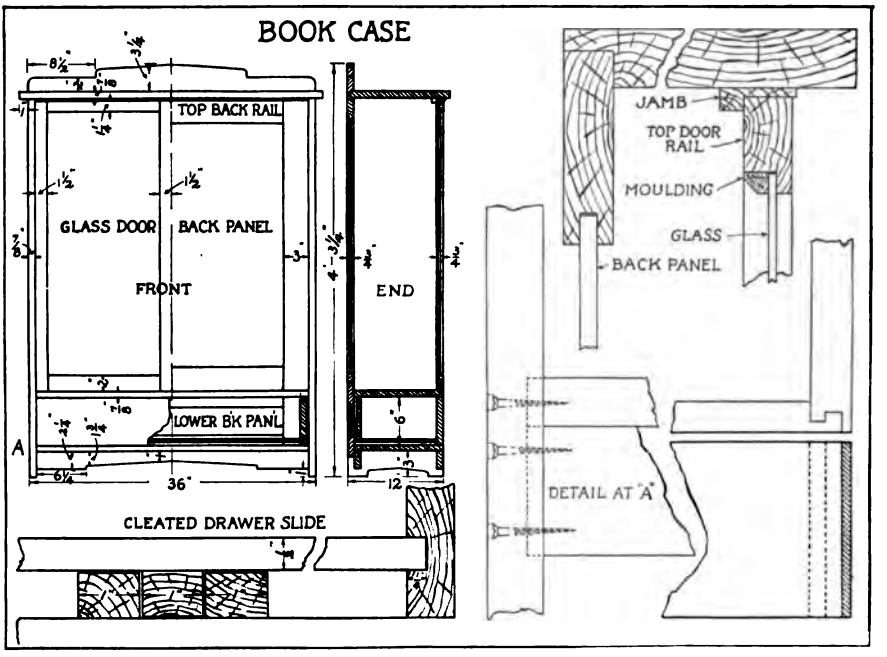

Fig. 54—Working Drawing of Book Case.

Where the scale of a working drawing is given, it would seem unnecessary to include the dimensions on the work, but in all drawings it is customary to give the precise dimensions of all parts. The workman should not need to scale a drawing to find dimensions. The points between which measurements are taken must be shown by extension lines and arrow heads. Some draftsmen draw extension and dimension lines in red or yellow ink to distinguish them from the lines of the object. Black arrow-heads are made at the end of dimension lines. Dimensions should, so far as possible, be placed outside the object, and care should be taken to make all dimensions legible.

While Fig. 54 is a two-view working drawing, in reality it shows four views, besides details of parts. Note that one-half of the front view is shown in cross section, being cut through. The end view is also shown in cross section. Thus, not only dimensions are shown, but something of the internal construction. The types of working drawings are discussed more fully under the different headings.

MACHINE DRAWING

28. **Machine drawings** are working drawings applied to machine construction. In making machine drawings all the rules and principles learned under projection drawings are of value. Drawings are made showing the dimensions for the work when it is completed.

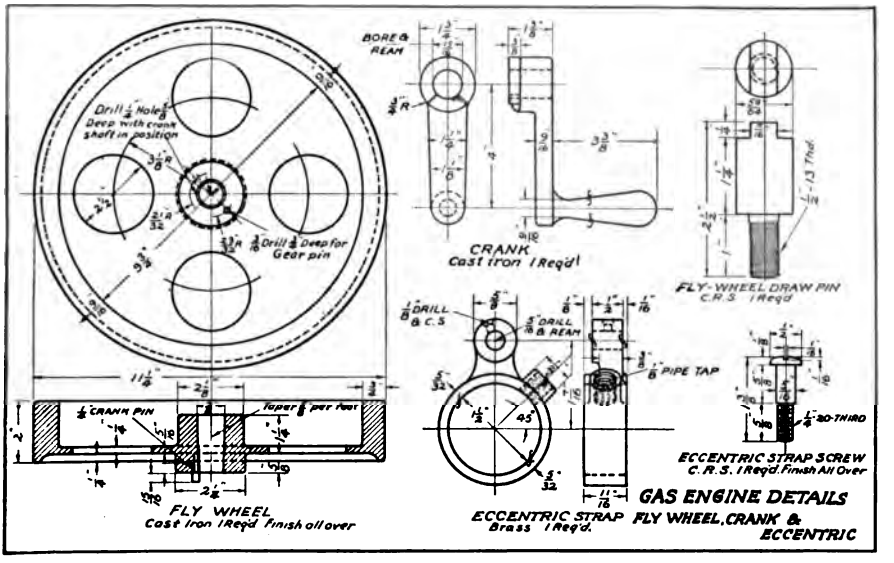

Fig. 55—Working Drawing of Gas Engine Details.

They are said to be made "finished size". To do machine drawing successfully requires not only ability to draw, but a knowledge of materials and acquaintance with shop practice. In designing machines, the design should show the machine as simple as possible. The strength of every part should be proportional to the work it has to do, but superfluous weight should be avoided. In design drawing, the preliminary layout of the entire machine is made full size, if possible, after free hand sketches have been made of the general ideas. Assembly drawings of various parts are made from the layout or design drawing.

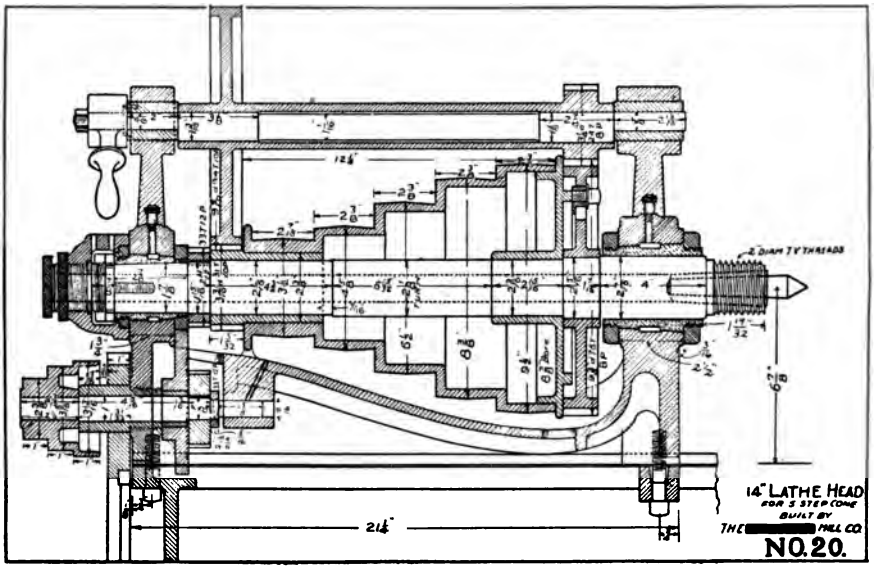

Fig. 56—Sectional Working Drawing of Lathe Head.

All detailed drawings are taken from the assembly drawings and checked with the layout. A complete set of machine working drawings consists of assembly sheets and detail sheets for each class of workmen, who will construct the machine, as the moulder, blacksmith, patternmaker, etc. Each set of drawings includes only those dimensions needed by the men for whom they are prepared. Thus, the set of drawings for the patternmaker would be different in some respects from the set of drawings of the same thing made for the blacksmith.

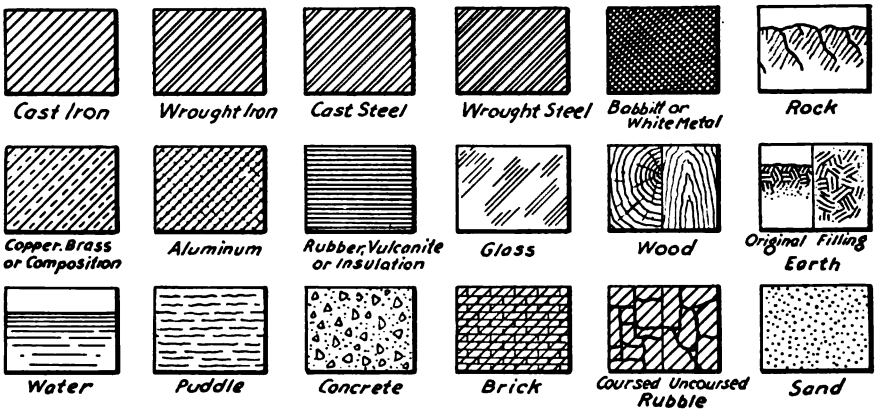

Fig. 57—Lining on cross sections to indicate kinds of material.

Some necessary information cannot be shown on the drawing, and in such a case notes may be added to give the information as, "two of these," "force fit," "drive fit," etc.

The illustration, Fig. 57, shows methods of lining on cross sections to show different kinds of material. Also, in every drawing the necessity of representing the fastening together of parts will occur. The methods are represented by certain conventions. Thus, in Fig. 58, **d**, **e**, and **f** show conventional method of drawing screw threads for bolts or studs less than one-half inch in diameter. Also **g**, **h**, **i**, and

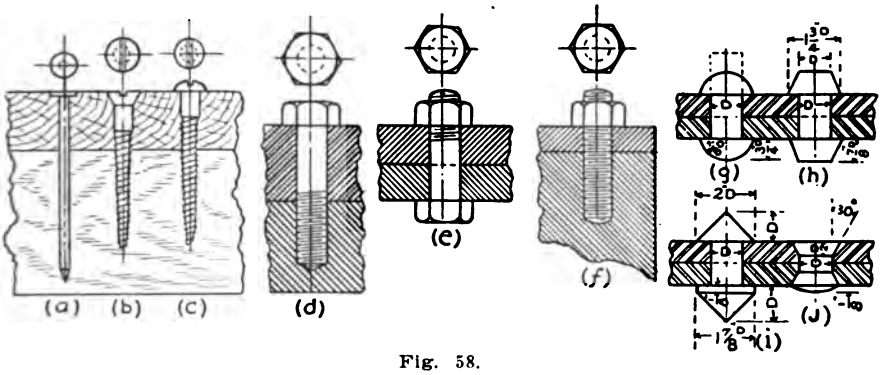

Fig. 58.

j show rivets holding together plates of steel. These are only a few of the many conventions used in machine drawings, and others will be noted as different machine drawings are examined.

Figs. 59 and 60 show different steps in a machine drawing. Fig. 59 shows a preliminary pencil sketch of a bracket to go on the frame of an automobile. Such a sketch is merely for the use of the draftsman and is not taken from the drafting room. Fig. 60 shows a dimensioned finished pencil drawing of this part. In this case, as the drawing will not be handled often, it is not inked in, but is left in pencil. Blueprints may be made from this pencil tracing, but the usual practice is to make the prints from inked drawings.

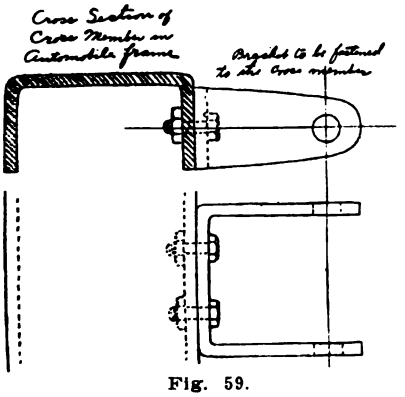

Fig. 59.

Fig. 61 shows an assembly drawing of the exhaust cut-out of an automobile, and Fig. 62 shows a detailed drawing of one part, number 33053-D of the assembled drawing.

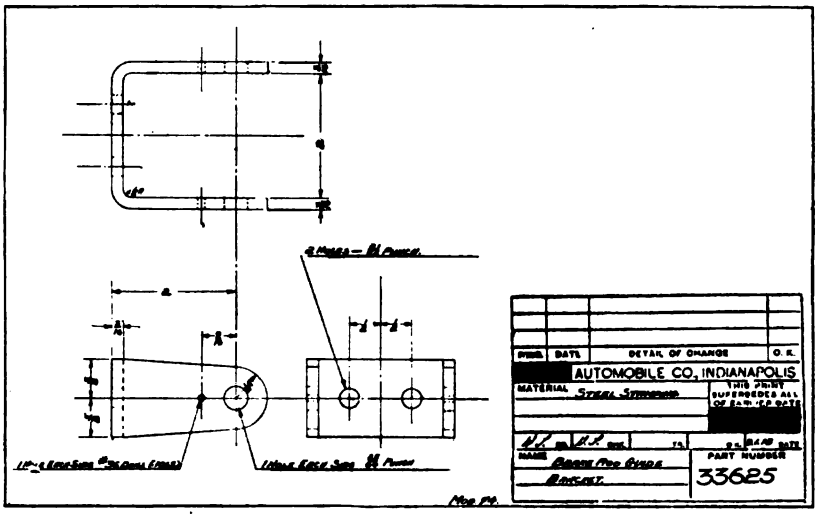

Fig. 60.

It is interesting to note how the changes are made on the detailed drawings from time to time. Such a change is shown on these two drawings. In the assembly drawing the part number 33053-D appears different than it is in the detailed drawing. The two are numbered the same and while all changes are kept on the detailed drawing, the only change on the assembly drawing is that of the suffix letter, which refers to the proper detailed drawing. On the detailed drawing the piece was changed from number 33053-C to 33053-D on the date 5-20-17. On that date, the dimension at (D), as marked on the drawing, was changed to five-sixteenths. On the same date, the number 33053-C became 33053-D on the assembly drawing. The next change on the drawing will be indicated by the letter E and the number will become 33053-E. (E) on the detailed drawing will explain the change. In this manner the drawings are not changed, unless the part is redesigned, but at all times accurate tab is kept on all changes which the piece has undergone, and all dimensions are corrected accordingly.

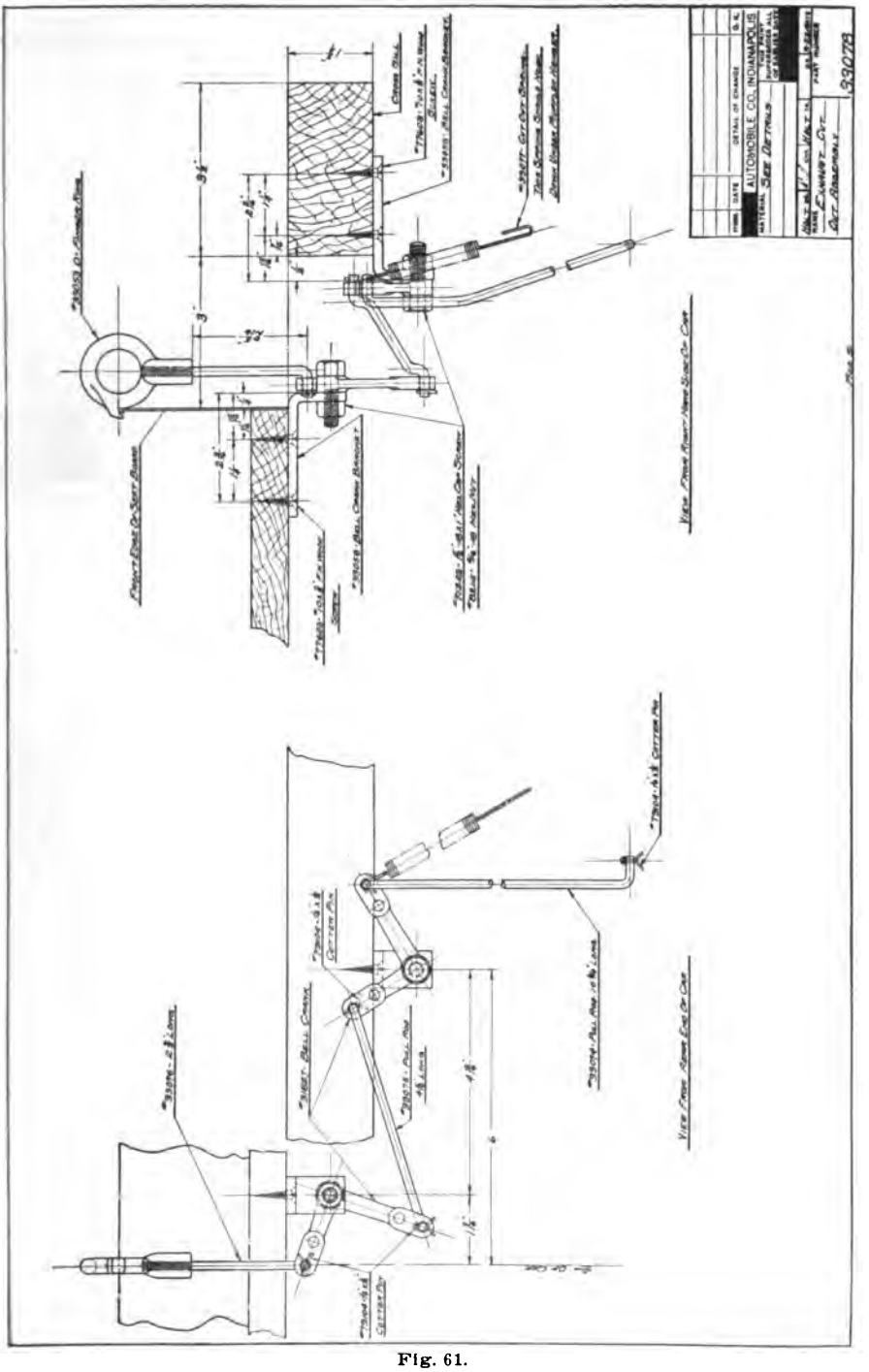

Fig. 61.

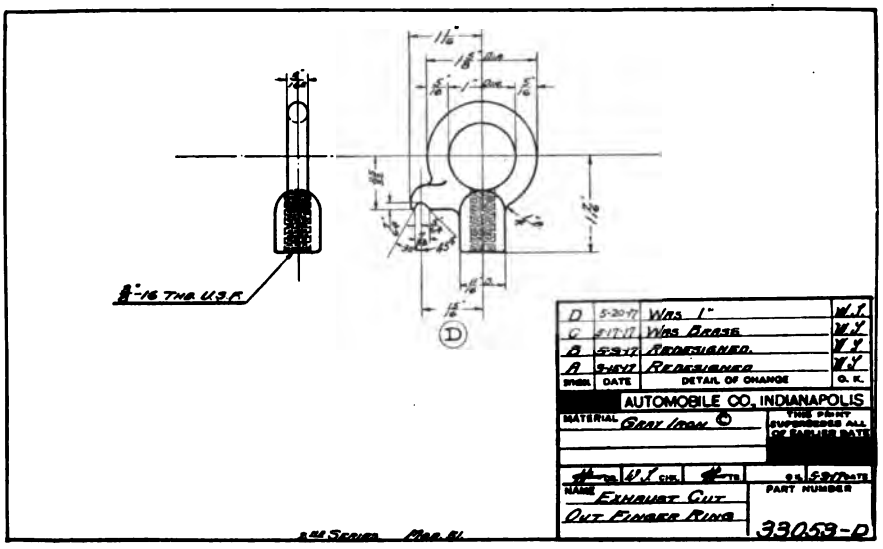

Fig. 62.

TOPOGRAPHICAL DRAWING

29. **Topographical drawing** is the method of representing the topography or surface contour of any section of country. Maps or photographs are made of the section to be covered, then, with surveying instruments, the heights of elevations are taken and laid off on several lines. The distance between lines and heights of elevations give the information needed to make a topographical map. In railroad construction, crews of men are kept busy taking measurements and constructing maps, contours and sections. Fig. 63 shows the contour of the land around a golf club-house, and above are sections taken along the lines AB and BC of the contour map. Highway commissioners have such maps made for the construction of highways, drainage systems and irrigation projects. Topographical drawings are useful in war, indicating approximately places for batteries, camps, trenches, etc.

Civil engineering is a large branch of general engineering and includes the subject of topographical drawing. To become a surveyor, mining engineer, map maker, army engineer, drainage engineer, etc., includes a study of topographical drawing as a part of the civil engineer's work.

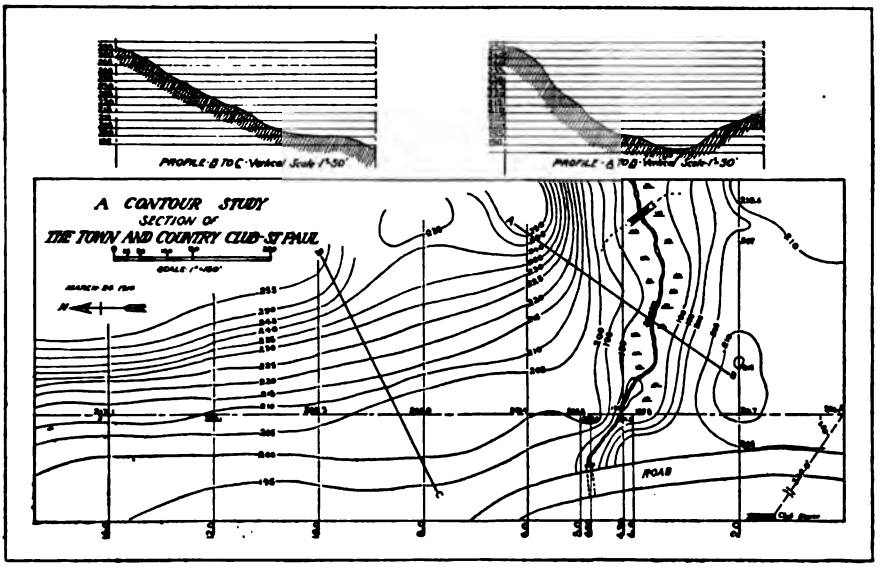

Fig. 63.

BLUEPRINTS

30. It is necessary to make several copies of each drawing made for shopwork or building construction and the blueprinting process has been developed for that purpose. Blueprinting is a process of printing drawings on paper which turns blue in developing. Usually a pencil or pen drawing is made on common paper and over this is laid a sheet of tracing paper or cloth and the drawing traced in ink. Some draftsmen make their pencil drawings directly on the tracing paper or cloth and then ink them in. The tracing is spread out on a piece of glass in a blueprint frame. A piece of blueprint paper is placed face side against the tracing and in this position exposed either to sunlight or electric light. The light produces a chemical change in the coating on blueprint paper, which is yellow before being washed. When proper exposure has been made, the paper is taken out of the blueprint frame and washed in clean water. The print is washed a few minutes, until the water comes off clear, then it is hung up or spread out to

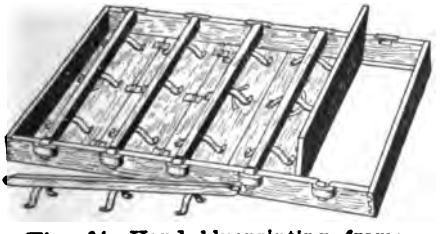

Fig. 64—Hand blueprinting frame.

dry. The yellow turns blue wherever the light has affected it, but underneath the black lines on the tracing where light has not affected the coating on the paper, the color is all washed off, leaving white paper. As many blue prints as are needed may be easily printed from one tracing. Not all papers produce blue colored prints. Some are coated with chemicals which, when exposed to sunlight and developed in special solutions, produce brown or black prints.

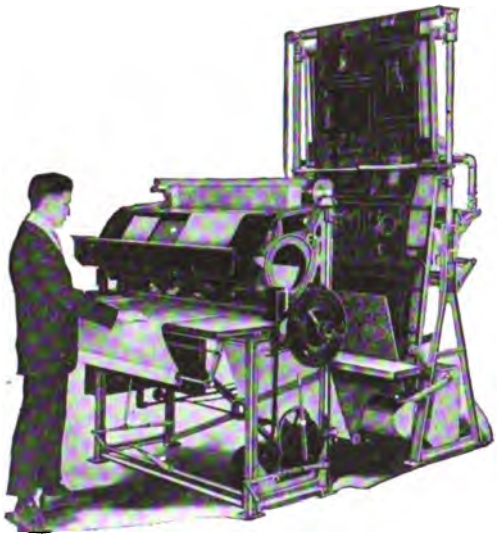

Fig. 65—Blueprinting machine.

In commercial blueprinting establishments, machines perform these operations. Prints can be produced more rapidly than by the hand-frame method, and as the exposure to light is mechanically operated, the prints are more uniform in color and distinctness of lines.

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SECTION SIX

PRE-VOCATIONAL SHOP WORK

By

EARL D. HAY, *Instructor in Industrial Dept., State Normal School, Oshkosh, Wis.*.
RAYMOND C. KEOPLE, *Supervisor of Manual Training, Rochester, N. Y.*
R. S. WHITING, *Architectural Engineer, National Lumber Manufacturers Association, Chicago, Ill.*
J. E. RAY, *Instructor of Bricklaying, Stout Institute, Menomonie, Wis.*
H. COLIN CAMPBELL, *Director of Editorial Bureau, Portland Cement Association, Chicago, Ill.*
H. F. GOOD, *Instructor of Gas Engineering, Stout Institute, Menomonie, Wis.*
J. J. RITTER, *Director of Industrial Work, Ft. Wayne, Ind.*
H. H. HARRISON, *Director of Industrial Work, Marshall, Mich.*
H. T. PURFIELD, *Instructor of Forge and Foundry Work, Ft. Wayne, Ind.*
EDWARD E. GREENE, *Instructor of Sheet Metal Work, Arsenal Technical Schools, Indianapolis, Ind.*
E. C. GRAHAM, *Vocational Director, Evansville, Ind.*
H. C. MILNES, *Instructor of Machine Shop Work, Stout Institute, Menomonie, Wis.*
R. F. JARVIS, *Instructor of Forging, Stout Institute, Menomonie, Wis.*
R. W. HASTINGS, *Practical Arts Department, Chestnut St. Junior High School, Springfield, Mass.*
R. W. AUSTIN, *Welding Expert, Chicago, Ill.*
C. S. GOLDSMITH, *Supervisor of Industrial Arts, Carlstadt and Oradell, N. J.*
EDWARD F. WORST, *Supervisor of Elementary Manual Training and Construction Work, Chicago, Ill.*
F. B. MCELROY, *Instructor of Industrial Arts, Washington School, Indianapolis, Ind.*
RALPH W. POLK, *Director of Vocational Instruction, St. Joseph, Mo.*
FRANK M. TREAT, *Instructor of Industrial Arts, Indiana University, Bloomington, Ind.*

PRE-VOCATIONAL SHOPWORK

1. All men who work have a place in industry and each may be classed in one of two groups, skilled or unskilled. Operations performed by all these men may vary from the most simple ones to difficult, intricate, and exacting processes. A man may use a single hand tool, or manipulate, day after day, a machine that performs but one operation, or he may use many tools and machines, and work with various materials. The skilled man is highly developed in the performance of his duties. He executes intricate pieces of work that require the exercise of a high order of intelligence. Skilled workers include the expert workman, the mechanic, the artist, the scientist, the superintendent, etc., and form a vast army of men. The unskilled man fills those positions requiring little ability except muscular development. He may be very efficient at his particular task but, usually, left upon his own resources could not go ahead as the skilled man would do. However, unskilled men are skillfully utilized so as to secure increased production. A boss or foreman skilled both in the work and in handling men directs them in the order and manner of procedure, and the system which has been developed enables them to do more work than they could do without a leader. Whether a skilled or unskilled workman, a man must be able to follow the directions of foreman and superintendent and proceed with system and efficiency, in a manner that will produce the proper kind and amount of product in the shortest time.

The tradesman works in cooperation with other shop men using well defined methods which have been layed down by practice. However, it is necessary to modify these methods in each case according to tools and equipment at hand. If well suited and adapted to his vocation, he takes pride in accomplishing each task to the best of his ability. He will be punctual and persistent in his work, and will produce the largest possible quantity of work of the highest quality. Upon his ability to do this, his value in industry depends and likewise his advancement and remuneration.

In order to decide what one is best able to do and what to follow for a life's work, information on trades, materials, equipment, operations, etc., is not sufficient. The individual must actually do work in different trades; must for a time impersonate or think of himself as being a carpenter, mason, plumber, blacksmith, mechanic, or other tradesman and, as he does his work, follow well defined and practical methods, for there are always general principles which must be kept

in mind. Each person possesses some natural ability in one or more lines and some line of work has a stronger personal appeal than others. It may be difficult to determine the special line in which one may make the best use of his efforts, for one may have ability which is not manifest until he has actually been tried out in various kinds of work.

Therefore, to make complete the training which will assist in determining the vocation best for one to pursue, shopwork, made up of portions of the work of fundamental trades, is an essential feature. In connection with the study of any trade, pieces of work representative of that trade, should be undertaken and the following order of procedure should govern their accomplishment:

Having in mind a certain trade, the first consideration is that of determining the project or piece of work applying to that trade, which may be attempted. This work may be of two kinds; it may simply indicate the trade, or it may be an actual unit of work from the trade. The latter type of project is the more desirable in most cases. Projects for shopwork may be selected from those given in this section, or other projects from, or indicating, certain trades may be chosen. If the project selected is not suited to one's ability or equipment, its educational value is destroyed. There should be, if possible, a definite need for the object when completed in addition to the educational value of its construction. Based on the need and use of the object to be made, the shape, size, kind of material and arrangement are, in general, determined.

Next, sketches are worked out to show the general appearance of the object. A sketch shows few details and usually no dimensions.

From the final sketch, a working drawing is made. It may consist of any number of drawings, but enough views should be given to show all details and dimensions. See Art. 27, Sec. 5. Size, design, details, and arrangements of parts all depend upon the use for which the object is designed.

The kind of material used is determined by the use to which the object is to be put, by the availability and properties of the material, and its cost. The properties of the material used must meet the demands of the use for which the thing is made. If made for strength, the material must be strong; if made for beauty, the material must be either attractive or capable of taking an attractive finish, etc. The properties to be considered in selecting woods are given in Arts. 3 to 13, Sec. 2; in selecting metals, Arts. 177 to 191, Sec. 2. Other materials are included under Arts. 192 to 280, Sec. 2.

Getting out Materials (Stock).—The amount and sizes of ma-

terials are determined from the drawings and, together with the kinds, constitute the bill of materials. After the bill of materials has been made out and the items obtained, the construction begins.

Construction.—The construction varies with every problem and depends upon the materials, their properties, use of the object, cost, etc. Methods used should, wherever possible, be those used in the trade. Where a method used is not common to the particular trade, the trade method should also be understood, together with the reason for not using that method in the object being made. Where a number of methods are used for doing a certain thing in the trades, each should be understood with its advantages, and disadvantages.

Assembling.—Nearly every project must be assembled and this operation varies from the simplest construction work to the most complex. Methods of assembling depend upon materials used, and their construction. Problems of assembling are as varied as methods of construction, but there are, in general, definite methods used in the trades which should be followed in all except special problems. The tradesman must meet all these problems and, upon his ability to solve them quickly and efficiently, his success partly depends. Where special problems come up, a suitable method for assembling must be developed.

Finishing.—In finishing work in the school shop, some trade methods can be only seldom used. For example, in the commercial plants, metal parts are sometimes painted by dipping; fixtures are lacquered by spraying and wood parts varnished by sprays. However, the same results may be secured by using the same kind of finishing materials in a different manner. In the cabinet factory, the sanding may be done by power, while in the school shop it may have to be done by hand, but the results are similar. The use of fillers, stains, paints, varnishes, etc., are explained under Arts. 117 to 122, and 125 to 128, Sec. 4.

Suggestions for Original Work.—While design and construction must always depend upon the use of the object and the ideas of the person constructing it, there are certain principles that must be observed, if trade conditions are to be followed. Beyond the underlying principles, the individual should plan the work, as to size, shape, kind of material, design and finish in accordance with his own ideas. Principles included in the completion of a project may be further developed, extended and applied in succeeding projects.

Occupational Significance.—If the project is one which merely leads into the trade without embodying any of the trade processes,

a study of the trade or industry represented should be made in connection with the work. If the project is one including processes and practices in the trade, they should be studied in relation to the trade as a whole. Do not get the idea that the processes embodied in one piece of work give an understanding of the entire trade. Only a few processes at best can be performed in the space of a Pre-Vocational course and these can be used only as an introduction, as it were, to the industries from which the trades are chosen.

The projects given in this section include processes in various industries and are intended, in connection with the informational matter of other sections, to assist in determining that industry or trade for which one is best suited.

THE CARE AND REPAIR OF MINING TOOLS *

2. In the modern coal mines much of the work which was formerly done by hand tools, such as cutting and drilling, is now done by machine tools driven by compressed air or electricity. Never-the-less, there still remains considerable work which must be done by hand and a good miner takes care that his hand tools are in good condition. He knows that his daily output of coal depends on the condition of his tools as well as on his labor.

The principal hand tools of the coal miner are drifting and cutting picks, drill, sledge, coal shovel, fork, and lamp. He must either keep thees tools in condition himself or hire the mine blacksmith to do it. While the average miner does not do his own smithing, he finds it advantageous to know how it should be done in order that he may give the proper directions to the one who does the work for him.

A handle for drift pick (a new or second-hand pick), a worn coal shovel, and a coal drill bit will give excellent practice in repairing the miner's hand tools. These problems include putting the pick in proper condition for use by sharpening the points and inserting the handle, repairing the battered edge of the shovel, and sharpening the drill bit.

What is the difference between a drift pick and a coal or cutting pick? For what purpose is each used? Which has the greatest amount of curvature in the point? Why is the eye of a pick made in such a way that the pick is slipped on over the handle? Why not have it made like a hammer handle and wedge it on in the same way? Of what materials is a pick made? What is meant by the term "second growth" as applied to hickory handles? What has evidently been the nature of the temper in the point A to cause it to curl? Or point B to cause it to break off? See Fig. 1.

Make a working drawing of a drift pick showing the manner in which the points were welded to the eye, and a drawing of a railroad pick showing the difference between the points.

To sharpen a pick, first straigthen the point, if bent, and draw it out in the shape of a square pyramid from an inch and a quarter to an inch and a half long, depending on the size of the pick. Be sure the point follows the arc

* By Earl D. Hay, Instructor in Industrial Department, State Normal School, Oshkosh, Wisconsin.

of curvature of the body of the pick as at C and not as at D or E. Next harden the point and draw the temper the same as for a cold chisel or a trifle softer. The handle is now fitted to the eye so that, when the pick is dropped over the handle and driven home, the end of the handle will be flush with the outside face of the pick and will fit the eye perfectly. If the handle is poorly fitted, it has a tendency of creeping back on the handle in a very annoying manner.

To dress up a battered shovel, the curled edges should be flattened out on the anvil and then the edge of the shovel should be cut off squarely back of all broken parts. Grind off the corners and file almost to an edge.

Sharpening a drill presents still a different problem. The churn drill is shown at F and the boring machine bit at G. While either kind may be considered here, the churn drill bit is more easily secured and handled in the school shop. First, spread the point to a width equal to the diameter of the hole to be drilled which always must be greater than the size of the shaft of the drill.

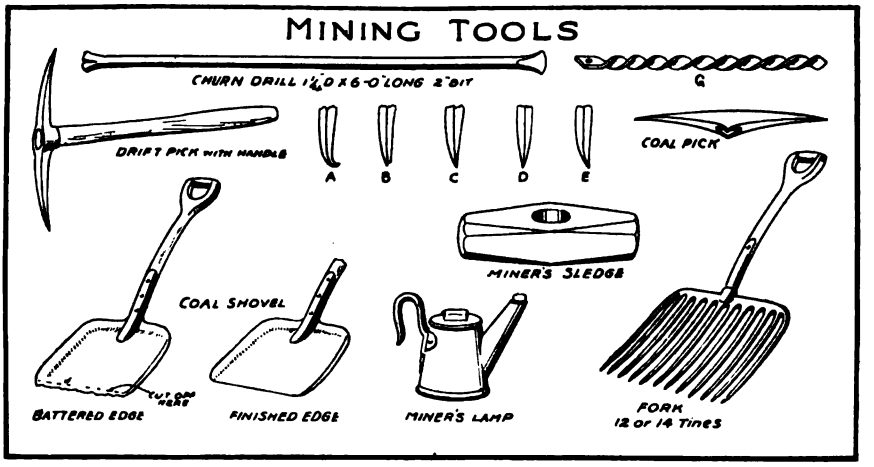

Fig. 1.

Next, draw it out wedge-shaped and almost to an edge. The end of the drill now has the appearance of a wedge about one and a half inches to two inches in length and slightly rounded on the end. About two inches of the point is now hardened and the temper drawn to a purple. The edge is ground sharp at a short bevel. See tempering in Art. 29 of this section.

Of what material is the drill made? What precautions should be taken in heating the point? Why give the drill a harder temper than the pick? Describe the action of the two kinds of drills used in coal mining.

Wood tool handles may be oiled to protect them from the moisture in the mine.

After finishing an exercise like the one given above, the student will probably be able to find many other tools about the home or farm which need repairing or putting in shape for use, and which, unless repaired, would be cast in the junk pile as useless. He may find such tools as axes, hammers, spades, spading forks, rakes, hoes, etc., which may be made usable by adding new handles or other slight repairs at a cost far below the purchase price of a new tool.

The preceding exercises are a part of the work or working knowledge of a coal miner. The mining of coal is one of the largest and most important industries in the United States. Without coal the world would immediately become helpless. Almost all industries would be obliged to close and railway transportation would cease.

The miners are numbered by the hundreds of thousands. A small mine will employ 100 to 200 men. Besides the miners themselves, many drivers, machine operators, firemen, hoisting and electrical engineers, and other skilled mechanics are required.

Where are the principal coal fields located? How many kinds of coal are found in the United States? In how many ways is it mined? What is the yearly output? Name the various operations employed in mining coal and placing it on board the cars. How are mines ventilated? How is the water kept out or removed? Name the various methods of transporting coal in the mines.

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FOLDING STEP-LADDER-STOOL *

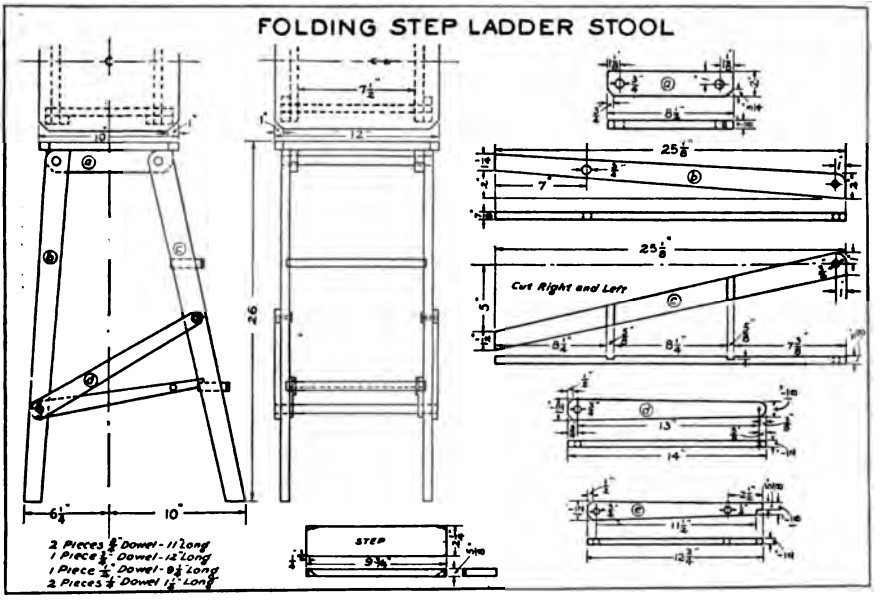

Fig. 2.

3. In the home there is a daily need for a small step-ladder and no kitchen is complete without a stool. Also, both of these pieces of furniture are useful in the shop and school room. The following project combines the two articles in one piece and, when folded, is so compact that it may be hung on a nail. All

* By Raymond C. Keople, Supervisor of Manual Training, Rochester, N. Y.

dimensions are shown in the drawing, Fig. 2, but, if a different size is desired, all detailed dimensions will have to be changed and a new drawing made.

The purpose for which it is to be used will largely determine the height and size. For ordinary use, the ladder-stool should be 24 to 30 inches in height. The one shown in the drawing is 26 inches high.

For durability, it is better to make this project out of some hard wood. Be sure that the wood is free from knots.

The construction is very simple. All dimensions shown in the drawing are for finished sizes. If a number of stools are to be built, jigs should be made so that the work will be more accurate and also to reduce the item of labor and time. Study the drawing carefully before beginning the work so as to have clearly in mind just what is to be done, and how it will look when completed.

The problem of assembling will offer no difficulties. Be sure that pieces B and C face in the same direction, otherwise the ladder will not fold. The ends of the dowels may be fastened by means of smaller dowels used as pins, or by

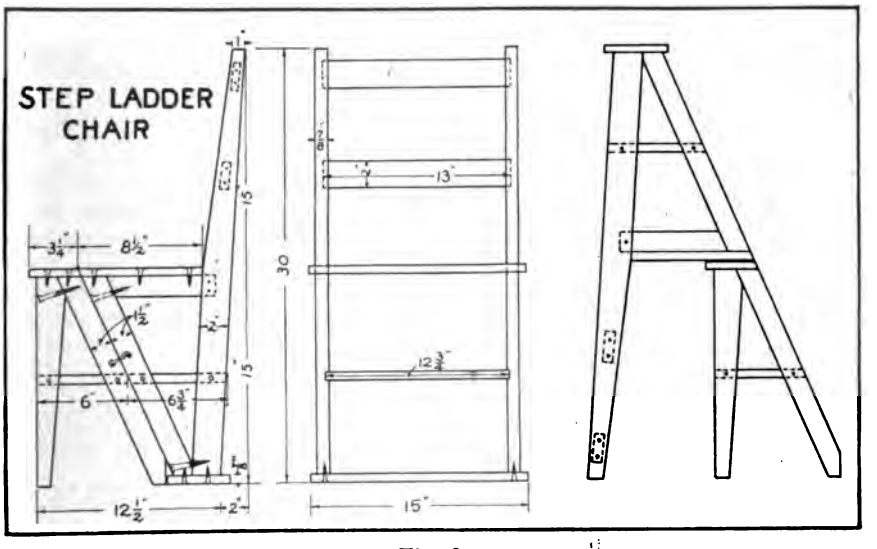

Fig. 3.

means of washers and cotter pins. See that the pieces which move do not bind too tightly.

The finish may well match the other wood work in the room where the stool is to be used. It may be painted or stained and varnished.

Fig. 3 shows a modification of this project. Many similar projects embodying similar principles are made by the carpenter and cabinet maker. While machinery is used largely in the cabinet factory where such projects are made commercially, yet the highest paid cabinetmaker is skilled with hand tools and could make the project as you have done. Skill with hand tools is a part of his job. Besides developing skill in tool processes and introducing trade problems, this work should lead to a study of design with utility, cost, etc., in mind.

Make a study of the different kinds of ladders made—step-ladders, extension ladders, etc. What is the cost of a 12-foot ladder? Make a visit to the factory of some ladder manufacturer. What are some of the principles involved in the construction of this ladder?

What relation has the length of piece (d) to the angle formed by (d) and (b)? If (d) were four inches longer, what effect would it have on the angle? What effect on the position of (b) and (c)? This project might well be used as a starting point of carpentry.

References: Problems in Woodwork, by Worst, The Bruce Publishing Co., Milwaukee, Wis.; Woodworking for Beginners, by Wheeler, G. P. Putnam's Sons, New York; Shopwork, by Rusch and Conway, Industrial Book & Equipment Co., Indianapolis; Shop Projects Based on Community Problems, by M. G. Burton, Ginn & Co., Boston.

HOG HOUSES *

4. There is no farm animal which needs care and protection more than the hog. The horse, sheep and cow are protected by a heavy coat of hair in the winter time. Chickens have a thick layer of fluffy feathers which keep their bodies warm, but a hog has nothing except a thin coat of stiff hair. Little pigs farrowed in cold temperature with no shelter generally die, and, even if they live, never thrive well.

Swine raising as a business is bringing about an improvement in housing conditions. Progressive farmers and hog raisers realize the money returns coming from proper protection for their hogs and have designed shelters which provide the maximum of comfort and convenience at a minimum of cost. While these structures are to be found principally on farms where hog raising is the chief business, they can easily be so changed in plan or size as to meet the needs of general purpose farms where hogs furnish but part of the total income.

The most important points in hog house construction are comfort for the animal under all conditions, conveniences for the care-taker in feeding and handling them, and good sanitation. To keep the swine in good condition, the house must provide sufficient warmth in cold weather and shade in summer.

The selection of the best possible hog house is largely a problem of local conditions. Thought must be given to the various factors connected with the actual use of the house in question. By studying the best points of the ideal house and the advantages of the proper location, it is easier to judge as to comparative values of different types.

Since the hog house is used almost every day in the year, its construction should be rather substantial. On this account, more money can be properly spent in its construction than on buildings used only a few months during the year. It should be so planned that the largest number of animals may be cared for with the least amount of labor.

The framing is usually a combination of 2x4 stock and heavier. For small buildings, the 2x4 material alone is suitable, but in the larger, permanent buildings heavier timber is necessary in order to make them substantial and durable. The walls are made close and warm. In the small portable building

* By R. S. Whiting, Architectural Engineer, The National Lumber Manufacturers' Association, Chicago.

shown in Fig. 4, they may be of single thickness, but, in the larger buildings, they are usually made double, either by siding up both the inside and outside of the studs or by putting on a double outside layer with building paper between. Shiplap for the inner boards and drop-siding for the outer ones give good results.

The question of floors is a very serious one which has worried hog raisers for many years. In a permanent building, the earth floor is decidedly unsanitary, so much that its use can hardly be recommended. Brick and concrete have both been tried, but in many cases they have been so cold that it has been found impossible for young pigs to live upon them. Houses that have been so equipped have had to be changed and a wood floor provided. This is partly due to poor construction, for it has been found that, if floors are sepa-

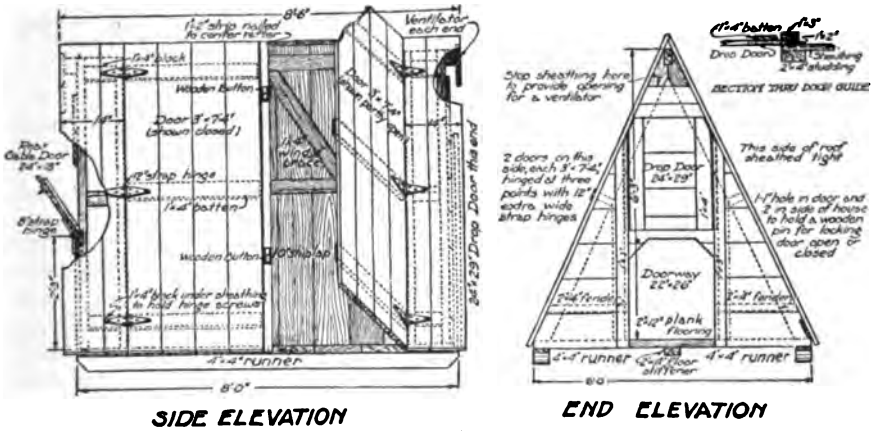

Fig. 4.

rated from the walls by a one-inch layer of asphalt or some such material, the passage of cold is materially lessened.

Wood floors, if properly constructed and used, are reasonably durable and, if made so that they are removable, there is no reason why sanitation can not be practiced in the hog house without any great difficulty. Indeed, many hog raisers find that a movable wood floor to be used in the winter farrowing is advisable. Creosoted flooring, or the creosote brush treatment of both floors and walls, is a sanitary measure and also adds to the durability of the wood.

All hog houses must be provided with sufficient window space for light and sunshine. These windows should be so inserted that they can be easily opened and closed.

The interior of large, permanent hog houses may be arranged to suit the convenience of the owner. The partitions may be made permanent or removable.

It is very easy to put too much money into any farm building, and the hog house is no exception. No one can afford, for any purpose, a building so expensive that the interest and depreciation will more than equal its value as a shelter. Even for the farm on which hog raising is a highly specialized business, it is doubtful whether it is advisable to make the cost per pen more than $50. In fact, half this amount can be made to give an exceedingly efficient building.

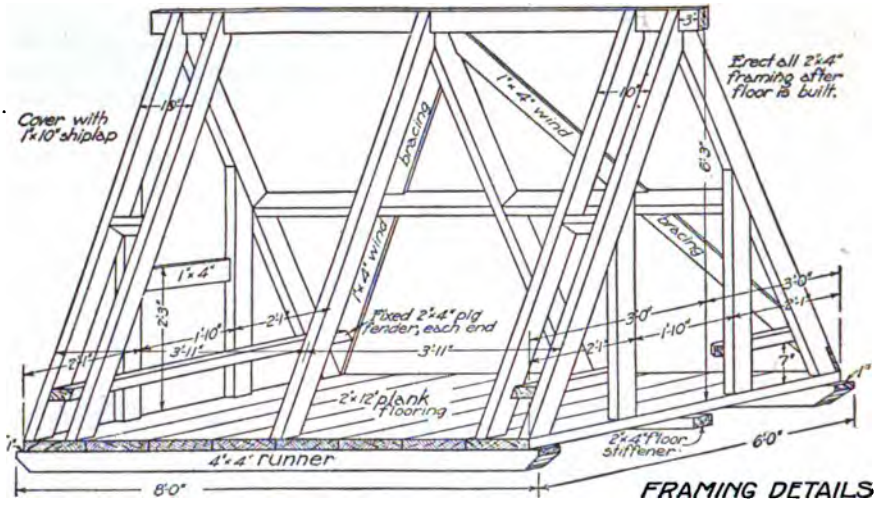

Fig. 5.

Fig. 5 shows details for the construction of a movable hog house. A number of such shelters will accomodate the herd on an average farm, and their cheapness, ease of moving from place to place, and their sanitary qualities make them quite desirable. Even on the farm having a permanent shelter, such additional shelters are handy. This project may be readily constructed by the student and furnishes excellent carpentry problems. In connection with the hog house, self feeders, both for forage and grain may be constructed. See Fig. 6. Such problems give additional work in designing and embody tool processes similar to those required in building the hog house.

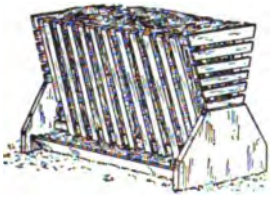

Fig. 6.

IMPLEMENT SHEDS *

5. With so much capital invested in equipment, the American farmer would certainly be a poor business man, if he did not take some means of protecting this equipment to reduce its depreciation, and increase its length of life.

A fair estimate of the average value of farm machinery on an improved farm is $1,000. No reliable figures are available to indicate the rate of depreciation of farm machinery; one farmer will take excellent care of his binder and it may do service for twenty or twenty-five years, while another farmer will leave his binder in the middle of the field where the last stalk of grain was cut, and it would be surprising, if his machine could operate satisfactorily for more than five seasons. To take ten years as to the average life of farm machinery is certainly conservative.

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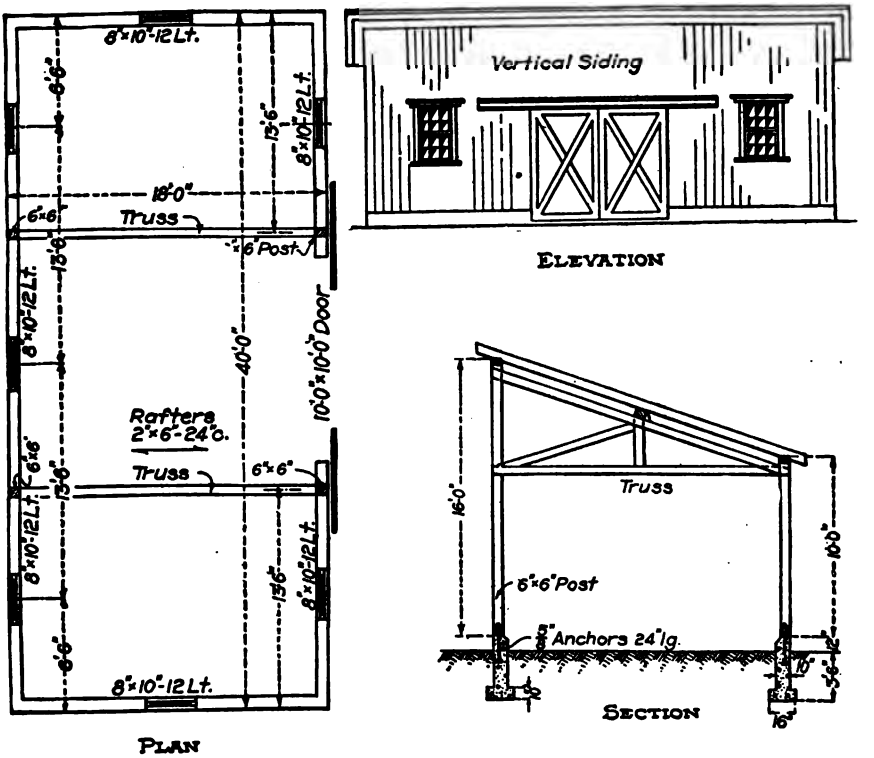


Fig. 7—Details of simple Implement Shed.

Note—Only one wide sliding door is shown, though another smaller door can be inserted, if desired. The truss construction is used above the wide door. Either vertical or horizontal siding may be used, the former being simple and satisfactory construction. The front wall may be omitted in localities where inclement weather is uncommon.

The life of many machines might be doubled, if the machines were properly sheltered and stored. On many farms, the saving would be a great deal more. Besides this, there is the benefit of having a machine that will operate when it is called upon to do so and the added value that an implement shed gives to the farm.

The careful farmer will have a machine shed and knows the value of paint, oil and grease in extending the life of implements. As a result, his implements are ready for use when spring comes and time is valuable.

Paint should be applied to all farm buildings. The initial cost of two coats of good paint is not prohibitive and the durability of the wood may be increased almost indefinitely, if the surface is kept coated with paint.

In preparing the design for machine sheds, one of the first considerations is that of economy. A machine shed is a building which is seldom used for any other purpose. It is not like a bin for the storage of grain where strength is an exceedingly important factor, nor is it like a barn where so many operations are carried on within. Consequently the simplest and cheapest structure

that is consistent with reasonable durability is the one that is the most advisable. Wood is a product available in every section and is the cheapest and most suitable material for the construction of an implement shed.

The planning of an implement shed will require data as to the number and size of machines and the amount of space that each will occupy.

In general the construction of a machine shed is that of the very simplest, yet utility and beauty can be combined very easily with simplicity. Since the building is not subjected to any heavy load, as would be the case with a crib or a barn, the framing is just sufficiently strong to safely hold the wall and roof covering and to prevent collapse of the building from wind, snow and ice loads. Very often 2x4's or 4x4's constitute the studs or posts and no heavier stock is used throughout the building. In wide sheds, it may be found necessary to use larger stuff and especially in the plate above the wide doorway.

The foundation of a machine shed will naturally not be designed for great strength, since the only load which it has to carry is the superstructure itself. A footing 12 to 16 inches wide at the bottom and extending down a foot or fifteen inches into solid soil will support a building of this kind. However, if a concrete floor is put in the building, as is sometimes done in the more expensive ones, it will be well to extend the foundation wall and footing to a point below the frost line, which will vary according to climate.

Sills are usually not necessary in the simple framing of machine sheds. The posts can be set directly upon foundation walls and fastened in any one of many different ways that have been devised. Timbers are more subject to decay at the ends than elsewhere, consequently it is advisable to treat them at this point with a preservative such as creosote. This will add greatly to their durability. The foundation wall should be brought up some distance above the ground, so as to further protect the bottom timbers from moisture. This above ground extension must be omitted at doorways.

A floor may or may not be used, as the owner may desire. It is likely to prove somewhat expensive in first cost and in maintenance, though for convenience it is much to be desired, especially if any repair work is to be done in the building.

The roof may be almost any style from the simple, single-pitch shed roof to the modified shed roof or the ordinary double-pitch, gable roof. It is desirable that the pitch should be no less than one-quarter in order to get the greatest life out of the shingles, which are likely to collect moisture and give shorter service where the pitch is too flat.

One of the most serious problems in the design of a machine shed is the insertion of doors. Wide doors are an absolute necessity, especially for certain machines. It may be necessary to provide an opening 12 or even 14 feet wide. This leaves a long, unsupported section of the plate directly above the doorway. To keep it and the roof from sagging, special provision must be made either by putting in an exceptionally strong plate at this point, or by building up a small wooden truss.

Strong framing is necessary to insure durability in this structure. Members may be solid or built-up. Doors may be located to suit requirements.

The doors themselves should be very solidly and substantially made. It is a matter of good practice to have as few doors as possible. A door wider than four feet should not be swung on hinges, as it is sure to either pull out the hinges or to sag badly. Sliding doors are to be recommended in preference to hinged doors.

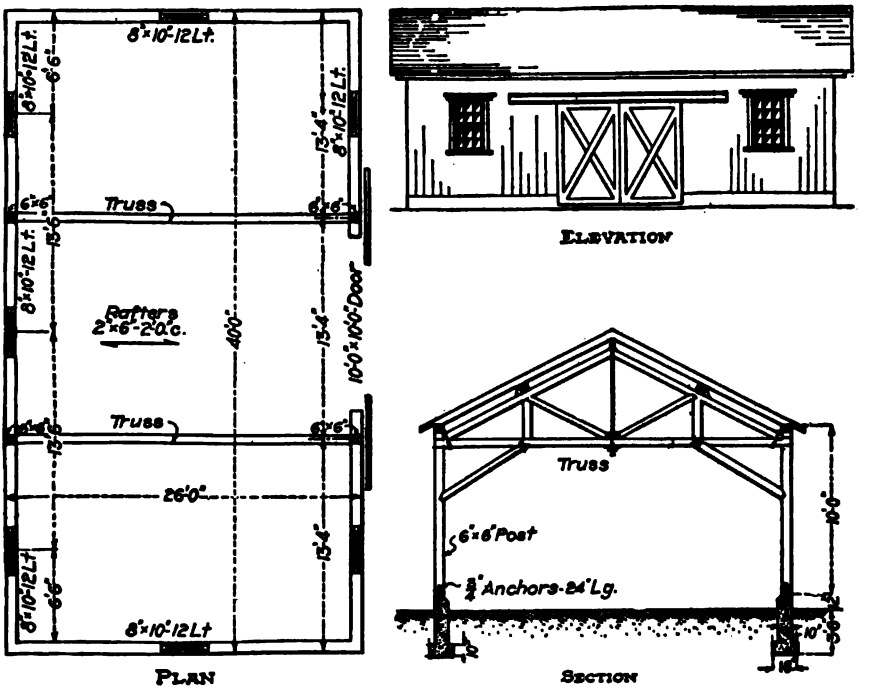


Fig. 8—Details of a wide, enclosed Implement Shed.

The needs of the average farm for a cheap, easily built implement shed are met by such a building as shown in Fig. 7. The framing consists of 6x6 posts set on a light 1:2½:5 mixture concrete foundation at intervals of eight feet, the plate consisting of two 2x6's. Short diagonal braces can be set in underneath between the plates and the post, in order to give the plate further support. The rafters for a span of 18 feet should be at least 2x6 and better, 2x8, set not less than two feet apart on centers. The wall covering may consist of vertical siding, either 10 or 12-inch boards, with the cracks covered by ogee battens. For horizontal siding, studs are necessary; these should be 2x4's, placed not over 3 feet apart. Either drop-siding, or novelty siding or ordinary weather-boaridng may be used, but the latter is somewhat light for a building of this kind and would probably not be as durable as the others.

The building may be entirely enclosed, having the doors on the high side. The practice of entirely enclosing the building is generally to be recommended, though sometimes for the sake of economy and convenience, it may be advisable to leave one side open.

CORN CRIB *

6. In the majority of instances, corn cribs are built with too little regard for strength and durability. The strain to which a crib or bin is subjected, due to

* By R. S. Whiting, Architectural Engineer, The National Lumber Manufacturers' Association, Chicago.

lateral pressure from the weight and settling of the grain is severe, particularly so at the floor and near the bottom of the walls. False economy is practiced when such a building is erected with a few stones or an occasional pier for a foundation and with light, unsound timbers for sills and framework.

Buildings for the storage of grains are of two kinds, those styled granaries and used for storage of small grains and those known as cribs and used almost exclusively for the storage of ear corn. As far as the general design is concerned, principles which apply to one type will apply equally to another. However, granaries must have tight walls and floors, while cribs should have walls with air spaces which permit ventilation. Then, cribs must be made narrower than granaries in order to make provision for the removal of considerable moisture which is given off by drying corn.

Little information is available concerning the lateral pressure on crib walls due to the weight of corn. However, the total lateral pressure on a section of crib wall one foot long and twenty feet deep is probably as much as 1,500 pounds. In a depth of 10 feet this value is about 400 pounds which shows that with deep cribs, especial attention must be given to the framing in order to make them sufficiently strong.

The foundation of a grain storage building must support not only the weight of the super-structure of the building, but also that of the grain. The best practice at the present time is to make use of concrete for the foundation. A good foundation can be made of a 1:2½:5 mixture of concrete, the foundation wall extending into the ground below the frost line. An adequate footing, at least twice as wide as the thickness of the foundation wall, is necessary. The width of the footing should be at least 16 inches, and in loose soils should be as much as 20 inches.

From some standpoints, it would be a desirable thing to use concrete for the floors of cribs and granaries. However, in some localities a decided objection exists to the use of concrete as a flooring material, based on the belief that it is retentive of moisture and will induce rot in grain. It is possible to construct a concrete floor that will be practically dry by making it of rich mixture having first provided for drainage from beneath the floor.

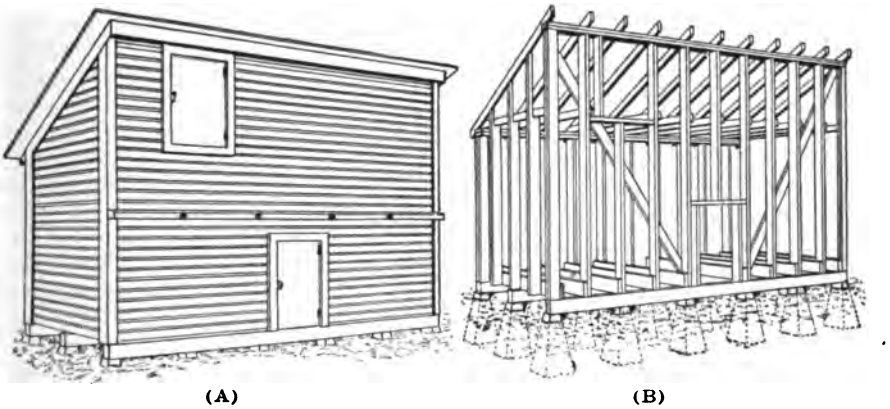
The objections that have been raised to the use of wood as a flooring material are, the difficulty of maintaining the floor in good condition and its liability to rot from dampness underneath. The first difficulty can be overcome by using heavier lumber of a better grade and putting it in with a proper support. The second objection can be removed by providing proper ventilation beneath the floor. The reason that so many wood floors in cribs and granaries rot is that rodents gain access to the space beneath the floor and, in their burrowing, pile up mounds of moist earth against the floor, when, of course, rotting will occur rapidly. Creosoting wooden floors and sills will help preserve them. Dipping is best, but a brush treatment will help.

The framing of a building for storing grain is equally as important as the foundation, because it is the framing which will have to withstand the lateral pressure. Seventy-five per cent of the failures of buildings of this kind are due to the bursting or racking of the walls because of insufficient rigidity. In the early days when lumber and labor were cheaper and many temporary structures were made, light framing consisting entirely of 2x4's or 2x6's served the purpose, though the depreciation was rapid and the effective life of the crib was seldom more than 12 or 15 years. Modern economy and efficiency demand a more permanent structure.

A few of the principles and practices employed in barn buildings can be applied very advantageously in the construction of buildings for grain. Heavy stock of 6x6 or 6x8 stuff, mortised and tenioned together, will provide a framework for the walls which will give excellent and satisfactory support. Lighter stuff can be used in conjunction with the heavy stuff as will be indicated in the subsequent plans. Particular attention must be given to crossties and braces to prevent the bulging of posts and studs. Adequate support must be provided for overhead beams.

Corn cribs are usually sided with 1x6 fencing or beveled siding, a 1-inch space being left between adjacent boards to provide for ventilation. The siding is usually put on horizontally and can be used more economically in this way, though sometimes in order to get a different effect, it is put on diagonally.

Most crib roofs have the ordinary construction of rafters, sheathing and shingles. This makes a very desirable type of roof since it gives excellent protection to the grain and since the roof itself will be more than ordinarily durable for the pitch of the roofs on cribs is generally at least one-half. The



(A) (B)

Fig. 9.—(A) Exterior of small Corn Crib which holds about 1,280 bushels. (B) Perspective of framing of small Corn Crib.

purpose of using a steep pitch on roofs of grain storage buildings is to provide room for the installation of conveyor equipment in the upper part of the crib. The roof will not help hold the crib together, its sole purpose being to shelter the enclosed grain. The framing of the crib should be made strong enough to support itself and any load which is likely to come upon it.

The plans in Fig. 10 illustrate the method of constructing a small corn crib, more or less temporary in character, to suit emergency conditions. If well constructed, it will be found to be quite durable. The main thing to be borne in mind is that thorough bracing to prevent bulging and racking is essential. The foundation consists of concrete piers at intervals of 4 feet. These piers are 6 inches square at the top, extending into the ground to a depth of 2½ or 3 feet and are 16 inches square at the bottom. Upon the piers are laid 4x8 sills and upon the sills joists of 2x8 stock properly sized and placed 24 inches center to center. The studs which are 2x6 are nailed to every floor joist, making the distance apart of the studs 24 inches. The studs on the low side of the crib are 8 feet high, those on the high side being 12 feet. At a height of 4 feet from the floor, four

⅝-inch tie-rods are put in and at the top 2x4's nailed to the studs prevent spreading of the walls. If only a temporary structure is desired, the roof may consist of the boards and battens, but, if the building is to serve for several years, it

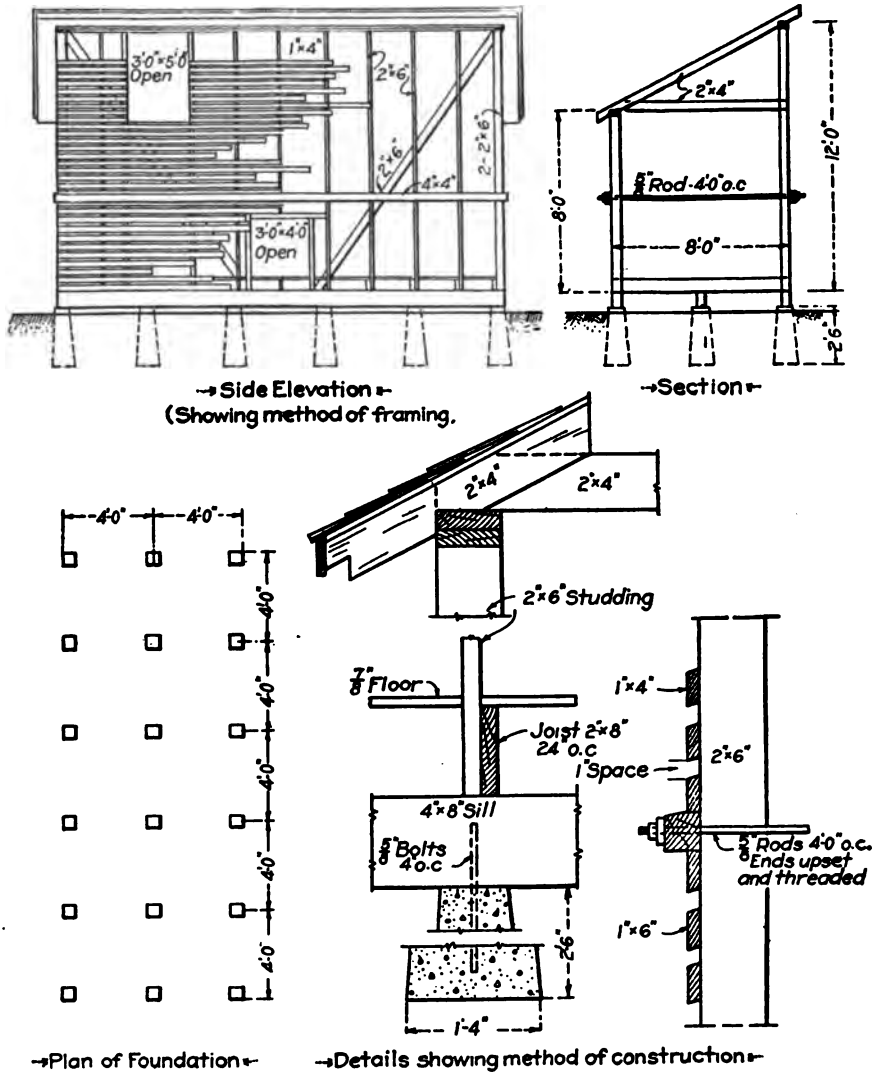


Fig. 10.—Details of small Corn Crib. Piers take the place of foundation walls. Doors for filling and emptying may be located as desired; the four lowest boards may be nailed on cleats and hinged to open outword and upward, for emptying into a dragbelt along the wall. Plain boards or beveled siding may be used for walls.

should have a shingle roof. The floor may be made of plain square-edged boards one inch thick.

Sometimes the walls of a crib of this kind are made slanting so that the width at the bottom is two feet or more less than the width at the top. The purpose in thus slanting the walls is to protect the enclosed grain from water dripping off the eaves, but it is doubtful whether the advantage gained is worth while. The width of the crib may vary from 6 to 10 feet. In Eastern states it has been found impractical to have a greater width than 6 feet. In Indiana and Illinois, 8 feet is the common width, while in Nebraska at the end of the corn belt and in a region where the general humidity is less, a width of 10 feet has been found satisfactory.

POULTRY HOUSE CONSTRUCTION *

7. The housing of poultry is one of the most important considerations connected with poultry production, for not only the comfort but the health and productiveness of the fowls depend on proper housing. A house that fulfills all conditions with absolute satisfaction has not as yet been devised. Certain tendencies in design, however, are predominant, and successful growers are gradually coming to the adoption of more or less standardized forms of poultry houses.

The old fashioned closed-type house is a thing of the past. It has been very clearly and definitely determined that the open-front type, (Figs. 12 and 13), as it is called, is the type of the future and this style of house, in a more or less modified form, is to be found in all parts of the country. The colony house, the brooder house, and the permanent house, all can have the open front to advantage.

The open-front house is tightly enclosed on all sides except the front, which should be the south side, and this should be partly or completely open to the outside air. This gives free ventilation without drafts. If cold, damp winds are likely to gain access to the house through these openings, they may be protected by a muslin or cheese-cloth shield to break the force of the wind and yet admit the air freely.

The first thing that must be borne in mind in the design of any house which is to shelter poultry, or any animal, is the location. Drainage should be given precedence, perhaps, to convenience, for no matter how conveniently located a house may be, if the drainage of the site is poor, so that the health of the fowls suffers, the only result will be failure. No condition is more productive of disease than dampness, and it is quickly fatal to fertility and production. If the ground has a gentle slope, preferably to the south, and, if the soil is loose and porous, no fears need be felt in this regard. If the site is not dry, it should be made so, either by filling or by putting in drains. Since it will undoubtedly be true that the women of the household will have considerable to do with the management of the poultry, it is logical to place the poultry house nearer to the residence than the livestock barns. Fowls are peculiarly susceptible to the ill effect of bad air, consequently, it has been found necessary to include in every poultry house some means of providing a ventilating system which will furnish an adequate supply of fresh air. This air must be supplied in such a way that no drafts will be produced. The open front, or curtain front, is the means which is usually adopted to obtain ventilation. Sometimes a further supply of fresh air is provided by making openings in the gable ends of the house. A layer of straw inserted near the ceiling will admit the passage of air through it, but will break up drafts so that they do not come directly upon the fowls.

* By R. S. Whiting, Architectural Engineer, The National Lumber Manufacturers' Association, Chicago.

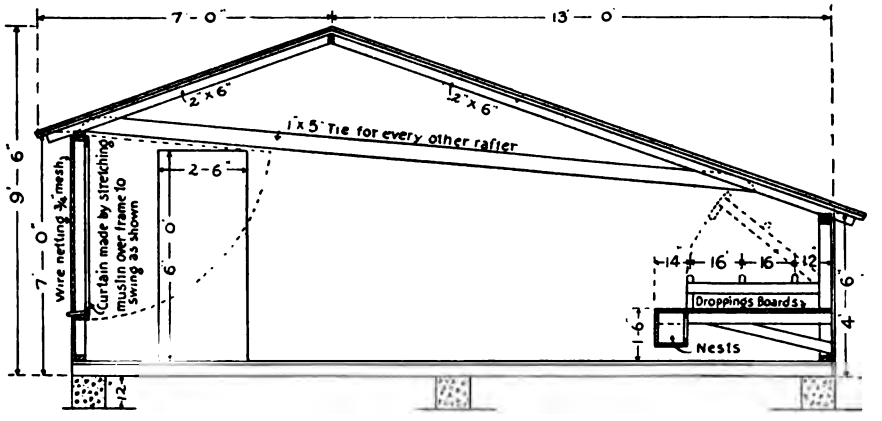
Sanitation, the keynote of modern building construction, applies to poultry houses. One of the greatest germicides is sunlight, and, since fowls are crowded into the house in the winter time, it is necessary that the maximum amount of sunlight reach them. Not only is the sunlight an efficient aid in the destruction of disease germs, but the heat furnished by the sun's rays will be conducive to the maximum egg production. In consequence of this it will be found advisable, in all poultry houses, to so build them that the full amount of sunlight available is utilized. A certain amount of the light will, of course, come through the muslin curtained openings, but some glazed openings should be provided through which the sunlight may come in directly.

From 2 to 5 square feet of floor space should be allowed for each bird. Fresh air should be provided by ventilation rather than by increasing the size of the house. The floor space is dependent upon the system and the breed of birds housed. Less space is required for birds under the colony system, where they have free range, than with the intensive system, where they have small fenced-in areas. The small breeds, such as Leghorns, require less space than the larger breeds, such as Brahmas.

Fig. 11.

The large colony house should be set on concrete or wooden posts or concrete walls. If wooden posts are used, they should be painted with a good preservative.

Where good drainage is available, dirt or gravel floors are satisfactory. In general, however, a tight board floor, well oiled with an ordinary floor oil to keep down the dust is the most satisfactory. The floor should be raised off



CROSS SECTION

Fig. 12.

the ground a sufficient height to prevent the harboring of rats, and also to allow a free circulation of air.

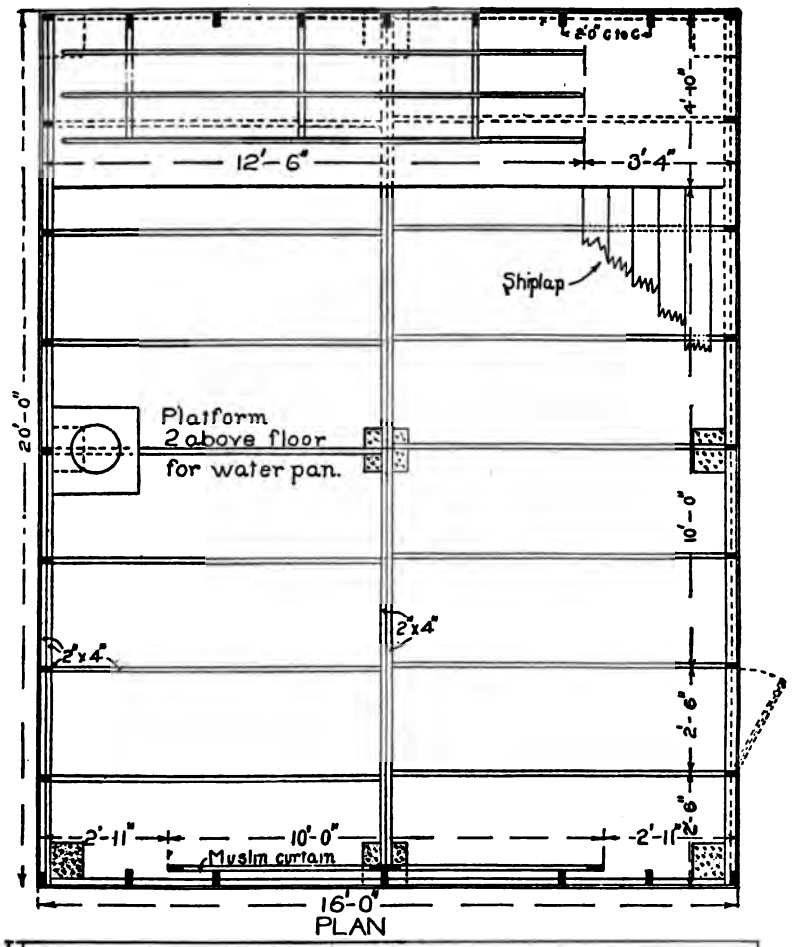


Fig. 13.—Details of house.

The back and two ends should be tight to insure against drafts. The front depends on the type of house. Too much glass should not be used, as it radiates heat very rapidly, and while warm in day time, is cold at night. Light-weight muslin or duck, tacked on frames, make a very satisfactory covering for the openings in the front of the house, as it will permit of free circulation of air without drafts. The front should be sufficiently high to allow sunlight to reach well back into the house during the winter.

The roof is a most important part of the house. It must be water tight. Shingle roofs are the most satisfactory, as they are cooler in summer and warmer in winter than those constructed with metal or prepared roofing. There are several types of roofs. For small houses the shed type is the best. It is the easiest to construct, and it allows a high front to the house. The combination type, as in Figs. 11 and 12, is adapted for houses over 16 feet and up to 24 feet wide. A satisfactory roof for this type of house is shown in Fig. 13, as it gives the best head room for the least cost, and reduces the amount of surplus air space.

Any durable lumber available can be used for the construction of the house. The outside material should be well seasoned to prevent excessive shrinking. Shiplap is very satisfactory for floors and sides of houses, as it can be laid up quickly and makes a tight floor or side. For floor joists and studding, 2x4's can be used. For roof rafters, 2x4's or 2x6's can be used, depending on the type of house.

Painting adds both to appearance and service. On new lumber, a priming coat should be used, and then covered by one or two coats of paint. Whitewashing the interior of the house adds to its appearance and is of assistance in keeping the house clean and fresh. An excellent whitewash and disinfectant combined can be made as follows:

Mix: 1 peck unslacked lime, 2 pounds common coarse salt, 1 gallon crude carbolic acid; dilute to 40 gallons with water.

An important feature of the poultry business, is the equipment of the houses. The principal equipment consists of receptacles for food and water, shipping crates, (Fig. 14), nests and roosts. Food receptacles consist of wet and dry mash hoppers, grit, shell, and charcoal hoppers.

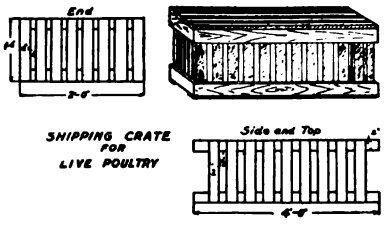


Fig. 14.

Nests are of two types; the simple open nest, and the trap nest. Both types are preferably placed under dropping boards, the nest being made accessible to the owner by a hinged door in front. The trap nest is sometimes desirable for the development of exhibition birds. Where large flocks are cared for, there is entirely too much labor attached to the trap nest.

Roosts should be of 2x3's or 2x4's, set on edge with the top rounded and set-in cross-pieces hinged to the wall, as shown in Fig. 12. The distance between roosts varies with the breed of bird. For Langshans and Brahmas, 10 inches; for Wyandottes and Plymouth Rocks, 8 inches; and for Leghorns and Minorcas, 7 inches, are proper. Roosts should invariably be located where they are out of the way of the attendant and not in a draft. They should be placed level. The ladder form of roost is undesirable.

A SERVICEABLE ONE-CAR GARAGE *

8. This is a serviceable one-car garage, which can be erected at small cost in any community.

The dimensions of this garage are large enough to permit the housing of practically any car manufactured. If desired, the building may be shortened, but it is advisable to build it rather long as there is seldom too much room in a garage.

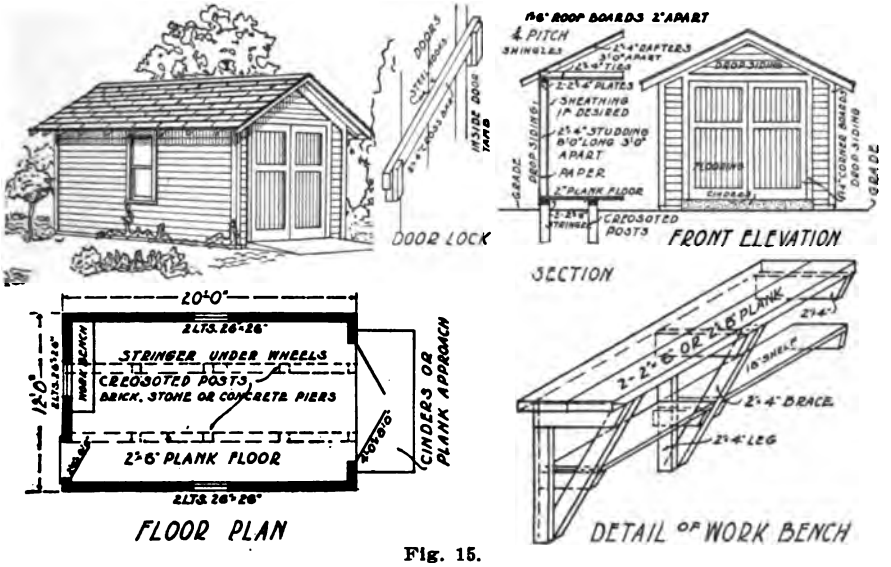


Fig. 15.

This building emphasizes economy in construction. It is designed primarily for those who do not desire to spend any more than is necessary. In a cold climate, it is advisable to sheathe the building inside and out, and also to ceil overhead. In erecting the building, use a durable wood or creosoted posts for foundation. Concrete or brick piers are good, but will add slightly to the cost and well creosoted posts will last a long time. The floor construction shown in the drawing is adequate and gives strength to the floor where it is most needed. The two stringers (two 2x6's spiked together) are directly under the wheels of the car as it stands in the garage. No other joists are necessary. The floor is constructed of 2x6 planks, dressed on the upper side. The rafters and studs are spaced 3 feet apart.

The dimensioned material and siding should be No. 1 grade, but the roof boards may be a No. 2 grade. Shingles should be of first quality and, on a small roof like this, may be laid 4½ or 5 inches to the weather. Cut or zinc-coated iron shingle nails should be used, rather than nails which quickly rust out. The large doors are made of dressed and matched boards, four or six inches wide, as preferred.

* By R. S. Whiting, Architectural Engineer, The National Lumber Manufacturers' Association, Chicago.

Paint the roof and sides inside and out with a good grade of paint, preferably one that is fire-resisting. A white or gray inside paint makes the garage much lighter and adds to the appearance. Use cement enamel paint on the plank floor so that oil and grease that drop from the car can be wiped up easily.

Get good hardware for the garage, including a lock that is not easily broken or picked.

Note especially the low cost of such a garage. This building is very attractive and, by painting, may be made to harmonize with other buildings. It adds to the value and appearance of the other property.

References: Carpentry, by Griffith, The Manual Arts Press, Peoria, Ill.; Constructive Carpentry, by King, American Book Co., New York.

MAKING A BRICK WALL *

9. Bricklaying is one of the oldest existing trades, dating back to at least 3000 B. C. Brick work can be found in most any part of the world and in any climate. The ancient Egyptians were quite proficient in the art of making brick. The "Wall of China" is a remarkable piece of ancient brick work built by Chinese about 200 B. C.

The brick layer's trade requires three years of apprenticeship. It is a trade that pays well and deserves the consideration of any boy who wishes to learn a trade. It is healthful work.

The lasting beauty and permanence of brick, their resistance to the elements and their fire-proof qualities place them among the most desirable of all building materials.

Comparing the cost of a brick and a frame dwelling indicates that a frame dwelling is in fact, as costly as one made of brick. The upkeep of a frame building including painting and repairing makes it rather an expensive building in a short time. The selling price of a frame building is usually below the original investment, while a brick building will generally sell for as much as its original cost. Also, the cost of insurance for a frame building is higher than for a fire-proof building.

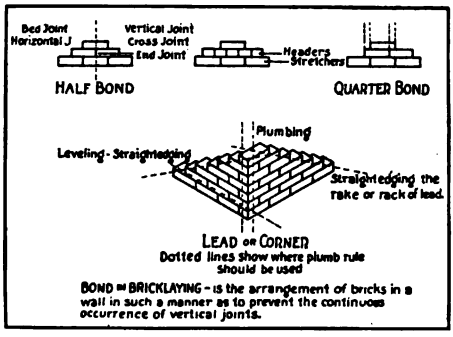


Fig. 16.

The length and thickness of a wall depends upon where it is to be used. In laying up a wall to certain dimensions, the bond is laid out to eliminate as many pieces as possible. The thickness is determined by the number of 4-inch tiers, laid beside each other. In a 4-inch wall, there would be one tier; 9-inch wall, two tiers; 13-inch wall, three tiers, and so on for any

* By J. E. Ray, Instructor of Bricklaying, Stout Institute, Menomonie, Wis.

required thickness. The measurements are always given on the drawing including length, thickness and height.

In making a general drawing, no consideration is given to the placing of each brick on the drawing, but in making a detail drawing of an arch, panel, or a design, each brick is shown on the drawing to be sure of the laying up of the brick according to the design. In detail drawings, it is necessary to draw to a large scale showing clearly how the brick are placed, whether as a rowlock, stretcher, header, or a soldier course. Joints are shown and their size specified.

For exterior work, a good, hard, well-burned brick should be used. All face brick should be uniform in thickness and length to present a neat appearance. Face brick vary in cost, depending upon the grade. They are made in all colors. Brick are laid up in the wall with mortar made of lime, sand and cement, which binds the brick into a solid mass. Mortars are frequently colored to present a contrast or harmony of colors.

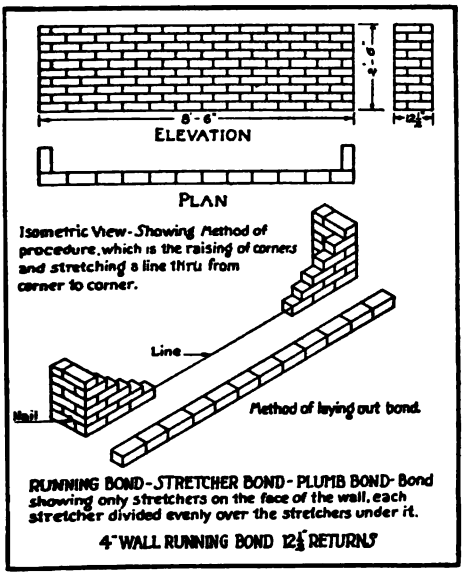


Fig. 17.

A variety of joints are used that set the brickwork off to advantage. The joints in general use are the "struck joint," "gouge joint" and the "rake joint." See Fig. 229, Sec. 4.

The planning of a piece of work depends upon whether it is to be a new piece of work or an addition to another structure. Then, there is the color scheme to decide, the kind of brick to use, and their cost, the width and style of jointing the brickwork, the location, and the purpose for which the brickwork is to be used. Openings, piers, pilasters, arches, and ornamental work are generally designed according to the size of the brick and the thickness of the mortar joints.

Before going thru the various steps in building a wall, it would be well to become acquainted with a few terms used in the trade. See references. Fig. 16 will give an idea of a few elementary processes involved in the construction of a wall.

Corners are raised first and the wall built with the aid of the line in between them. See Fig. 17.

To build any structure, the workman should be furnished with a detailed blue print.

To build a 4-inch wall according to the drawing, Fig. 17, the dimensions for length, returns, thickness and height are taken from the drawing.

The bond should be laid out to eliminate the pieces. See Fig. 17.

Returns must be square with the wall.

Skill is required in spreading the mortar in order to be able to raise the corners properly.

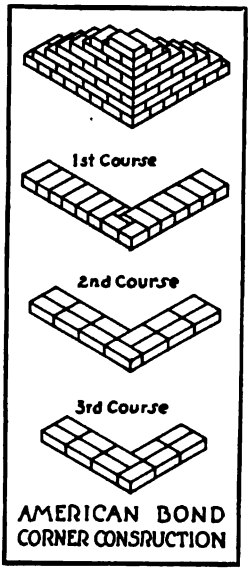


Fig. 18.

All joints must be uniform and the brick kept fairly clean. Corners are generally raised several courses high.

Three stretchers are laid on the line of the wall, leveled, straightened, and joints struck with the trowel.

A stretcher is laid at right angles to the corner brick, which makes the 12½-inch return. Level, straightedge, and strike the joints.

The second course is laid in a like manner, breaking the bond by lapping the vertical joints in the middle of the stretcher. Level, straightedge, and strike the joints.

The remaining courses are laid in a similar manner.

The corner is plumbed the third course and the last course, plumbing the corner a trifle scant, (battering in) or hanging in. This is done to allow for contracting of mortar and drawing corner out which has a tendency to overhang.

The opposite corner is laid up in the same manner, leveled and lined up with first corner that was raised.

A line is stretched tightly between the corners on the first course, and the brick laid to the line. Brick should be laid parallel to the line both up and down, and in and out. Caution should be used not to crowd the line. Strike each course as it is laid.

All walls from 9 inch up are laid in the same manner and involve the same tool processes. The outside 4 inch is always laid first, up to header high, and then backed up according to the thickness desired.

For explanation of the spreading of mortar, the cutting off of surplus mortar, and throwing up the cross joints, see Art. 214, Sec. 4.

Walls may be built in other bonds, such as the American and the Flemish bond. See Figs. 18 and 19 for the proper method of raising the corner and the construction.

When the student has gained some skill, there are many other problems that can be built besides the building of the wall, such as piers, chimneys, retaining walls, footings, foundations, putting in openings for windows and doors, etc.

The student can develop considerable skill only by diligent application, as the most difficult part is the developing of speed with accuracy. He can, by observation of the workman, gain many pointers in regard to the proper movements to gain speed.

Bricklayers make good wages and in towns and cities are usually in demand. For general information on this trade, see Art. 84, Sec. 1.

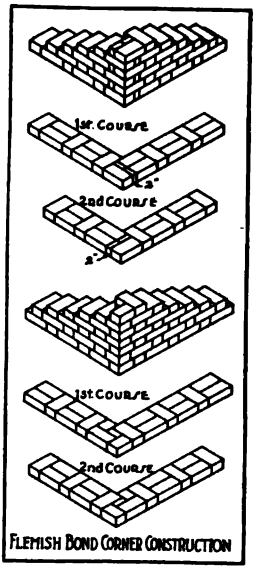


Fig. 19.

References: Kidder's Handbook on Building Trades; I. C. S. Handbook on Building Trades; Bricklaying System, by Gilbreth, The Myron C. Clark Publishing Co., New York; Practical Bricklaying, by Maginnis, Owen B. Maginnis, New

York; Practical Bricklaying, by Hodgson, Frederick J. Drake & Co., Chicago; Building Construction and Superintendence, Part I, Mason's Work, by Kidder, The Wm. T. Comstock Co., New York; Magazines—Building Age, American Builder, National Builder.

MAKING BRICK ARCHES *

10. Arches are used to span openings where a lintel or I-beam is unnecessary. In almost all of the ancient buildings will be found various kinds of arches. The thickness and depth of an arch depend upon the size of the wall, opening to be spanned, and kind of an arch used. An arch should be planned to correspond to the style of building. As a rule, arches of different styles should not be used in the same building. Arches must be constructed carefully and of first-class, strong material.

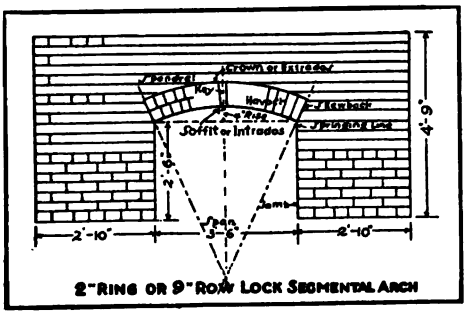


Fig. 20.

In building an arch, the workman should have a detailed blue print. To build a 9-inch rowlock, segmental arch according to the drawing, Fig. 20, the dimensions are taken from the drawing and laid out accordingly. The American bond is used and the first course is a header course starting from the corner with a header and a three-quarter. There are five courses of stretchers between heading courses. The bond is always laid through from corner to corner, or over opening, to eliminate pieces over the arch. The bond on the drawing has been laid out correctly.

Corners may be raised and a line used up to the springing line of the arch, or each pier may be raised separately. A center is made and put between the piers with the proper rise (4″) and braced. The lower edge of the arch is flush with springing line of the piers.

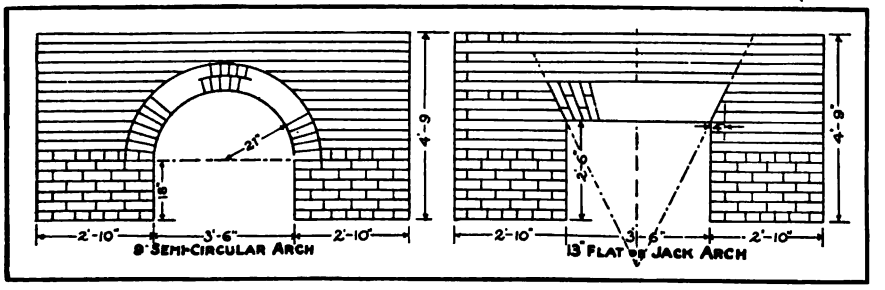


Fig. 21.

The corners are raised and the wall laid to a line cutting the three corners of the skewback. In laying the arch brick, the mortar is put on the brick and then the brick is laid. All arch brick must rest squarely on the center in order

* By J. E. Ray, Instructor of Bricklaying, Stout Institute, Menomonie, Wis.

to radiate properly. The keybrick must fit snugly and all oints flushed with mortar on the top when the first ring is laid. All joints should correspond with the joints used in building the piers. The second ring is laid in the same manner, keeping joints uniform regardless of where they come over the first ring. Key-in the center. Cut-over the arch to the line. Finish remaining courses according to the drawing.

The names of various parts of the arch should be memorized in order to become familiar with them. Careful study should be made, and the beginner should watch a bricklayer building an arch and setting the center, cutting one side of the skewback, laying and keying one ring over the center and cutting-over an arch. Various styles of arches should be studied. A semi-circular arch and a flat or jack arch are shown in Fig. 21.

The work of the bricklayers is needed in the construction of brick, or brick and stone buildings, brick veneer houses, chimneys, foundations, columns, etc. Bricklaying requires small expenditure for tools but considerable skill and speed are necessary. The wages are good. For more information on the trade, see Art. 84, Sec. 1; for required tools, etc., see Art. 17, Sec. 3.

References: See references under Art. 9.

BRICK CHIMNEYS *

11. Chimneys were first built of logs and plastered with mud, but with the manufacture of brick and the ease of building with them, brick chimneys came to be chiefly used. Chimneys must be strong to withstand wind and other elements, also fireproof, as carelessly built work is frequently the cause of fires.

Chimneys are generally spoken of with regard to the inside measurements of the flues. For example, 8"x8", 8"x12" and 12"x12" refer to the sizes of flue openings. The outside measurements depend upon the size of the brick used to enclose the desired flue. When a flue lining is used, which is the best construction, a 4-inch wall around the flue is usually sufficient . Chimneys of 3 or 4 stories in height should have a flue lining and an 8-inch wall. By referring to books, much may be learned regarding the proper sized flue to use and proper method of building same.

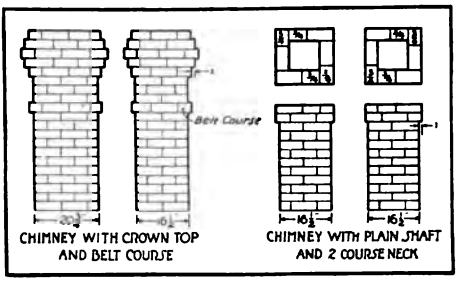


Fig. 22.

Materials and workmanship should always be of the best. Chimneys should be built of a hard, well-burned brick, using a good strong lime and cement mortar. Joints should be "slushed" entirely thru to insure an absolutely fire-proof construction.

In designing a chimney, ornamental work should be used sparingly, especially when it would interfere with durability. However, one may add some details which are pleasing and which present a good appearance without interfering with the strength and permanency of the chimney.

Practically the same tool operations are involved in laying brick on a chimney as in laying up a wall. To build a chimney with a crown top and an 8"x12"

* By J. E. Ray, Instructor of Bricklaying, Stout Institute, Menomonie, Wis.

flue (inside measurements) is an excellent problem. The drawing, Fig. 22, should be studied carefully. The dimensions may vary slightly according to the size of the brick used, but all joints must be flush and full of mortar.

The inside of the chimney should be plastered or parged, if flue lining is not used.

Care should be used in laying the first three courses to have the chimney square and cross joints not too large. All four corners must be kept plumb (a trifle scant) to insure a plumb chimney when the mortar is set. All courses must be kept level and joints uniform.

A trowel of mortar is picked up in one hand and a brick in the other. These two motions are carried on simultaneously for speed in working. This method is used in almost all brick work such as raising corners, laying up chimneys, piers, and putting in arch work.

A projecting course of brickwork is called a belt course.

The bond is reversed, using two $\frac{3}{4}$ or 6″ pieces on opposite corners. This is done to eliminate 2″ pieces.

No pieces under 4″ should be put in a chimney and the bond must always be maintained to insure strength and durability.

The crown is put on by reversing the bond when necessary in each course. Each course projects 1″.

It is advisable to lay each course dry to get an idea of the proper bond before setting the brick in mortar.

All projecting courses are leveled on the under side, or bottom edge and straightedged for "in and out."

The joints are struck as they are laid by striking with the trowel. When raking or gouging the joints, several courses are laid before striking.

The construction of a chimney may be modified in a number of ways. For practice, the same brick may be used to lay up a number of different styles of chimneys. Different methods may be used for lining, different sizes made, and different styles of ornamentation included. The project should give trade knowledge applicable to other kinds of bricklaying, as, for example, veneering a frame building with brick.

The bricklayer should have a good education. He works with other tradesmen and it is of great assistance not only to be able to follow directions but to read blue prints for brick construction or other building work, to know something of building stresses, strains, properties and kinds of mortar, etc.

References: See references under Art. 9.

TREE SURGERY *

12. Owing to careless methods of cutting large limbs from shade or fruit trees or to the fact that when such limbs are blown from the trees during windstorms, no attempt is made to protect the resulting wound, rot often develops at the seat of injury and soon the tree is in danger of destruction. There has been found a way to lengthen the life of trees that have been attacked by rot by filling the cavities produced with concrete.

If the work is properly done, trees may be given added life. In extremely

* **By H. Colin Campbell, Director Editorial Bureau, Portland Cement Association, Chicago.**

large cavities, it is sometimes necessary to reinforce the concrete with chicken wire mesh, bolts, small iron rods or nails.

Fig. 23.

Before filling the cavity with concrete, it must be cleaned out so that all diseased portions are removed and all fungus growth destroyed. This is done by cutting and scraping down to good, live wood, and coating the inside of the cavity with a germicidal solution as copper sulphate, or creosote. If the cavity is a large one, this treatment is followed by painting the cavity with hot tar to form a spring or expansion joint cushion to prevent the wood from cracking the concrete after it is placed. If the cavity is an open one from which the concrete may become loosened, the concrete may be firmly fixed in position by driving 20-penny nails part way into the wood all around the opening. See Fig. 23. In larger cavities rods, bolts or wire mesh may have to be used to keep the concrete from cracking under the bending of the tree from wind.

Fig. 24.

Concrete for filling the cavity is mixed in the proportions of 1 sack of cement

Fig. 25.

Fig. 26.

to 2 cubic feet of clean sand and 3 cubic feet of clean, well graded pebbles or broken stone. Enough water is added to form a quaky mixture, and this mixture is firmly packed in the cavity. If the cavity is so open that difficulty is encountered in placing the concrete, canvas or burlap may be wrapped around the tree to hold the concrete in place until it has hardened. After 25 hours, the canvas or burlap may be removed and the exposed concrete surface given a coat of cement paint, made by adding water to pure cement until the mixture is about the consistency of cream.

If the cavity was properly cleaned and the surrounding bark cut back all around the opening one-half inch from the face of the cavity, the growth of the tree will eventually inclose the concrete. The concrete filling will keep out moisture and preserve the tree for many years.

Tree surgery is a trade of its own, and is only one of the many trades which has made use of the peculiar and valuable properties of concrete. The architect, the metal worker, the sculpturer, the potter, the mason, the brick layer, all need to know something of concrete practice.

CONCRETE FENCE POSTS *

18. When wood was plentiful, it was common practice to use it for fences. As suitable wood became scarcer, post and rail fences were replaced largely by wire attached to wood posts. In some sections of the country, suitable fence post wood has become scarce and concrete has replaced the wood. Concrete posts have the advantage of being fireproof and rotproof and, if made well, are practically indestructible.

Concrete fence posts are of various shapes as square, rectangular, round and triangular. The dimensions are varied with the use for which the posts are designed. A square, tapering post, for example, one that is $3\frac{1}{2}$ or 4 inches square at the top and 5 by 5 inches at the bottom is an excellent problem for construction. Fence posts of this kind are usually about 7 feet long.

To make concrete fence posts, materials required are cement, sand, pebbles or broken stone, and water. One inch lumber is needed form which to make the form in which the concrete is shaped or molded. Four, $\frac{1}{2}$-inch, round or twisted square steel rods are required for each post to reinforce it. The tools necessary are a square pointed shovel, a mixing platform on which the concrete can be mixed without incorporating earth or other objectionable refuse with it, a steel rod or sharp-pointed stick with chisel edge for spading or puddling the concrete in the forms, a straightedge, and a wood float to strike off and smooth the top surface of the concrete after the form has been filled.

A plain rectangular post is of simple lines and can be illustrated with a very simple drawing. Such a drawing is shown in Fig. 27.

Any standard brand of portland cement will meet all requirements. The sand and pebbles, or broken stone, should be well graded from fine to coarse and free from dust, loam, clay or other foreign matter. The largest particles ordinarily should not exceed $\frac{1}{2}$ inch in diameter. They should be definitely proportioned. The recommended mixture for concrete fence posts is 1:2:3. That means 1 part cement, 2 parts clean, well graded sand, in which the coarser particles predominate and range in size up to $\frac{1}{4}$ inch in greatest dimension, and 3 parts pebbles or broken stones ranging from $\frac{1}{4}$ to $\frac{1}{2}$ inch. An accompanying table shows the

* By H. Colin Campbell, Director Editorial Bureau, Portland Cement Association, Chicago.

quantities of materials required for various mixtures to make a certain volume of concrete. After having calculated the volume of the mold (form) that is to be filled, it is an easy matter to determine from this table what volumes of the separate materials should be measured to fill the mold. An allowance of 10 per cent over and above that actually required should be made for possible wastage. Sand and cement should first be mixed dry, turning the two together several times until the mass has a uniform color. Then water should be added and the materials again mixed until they have a stiff mortar consistency. The pebbles or broken stone should be wet and then added to the mortar, all materials again being turned together and more water added, if necessary. A stiff mixture, yet one which on working or handling has sort of a jelly-like consistency, should be obtained. Enough of this mixture should be placed in the mold to fill it to a depth of ¾ of an inch.

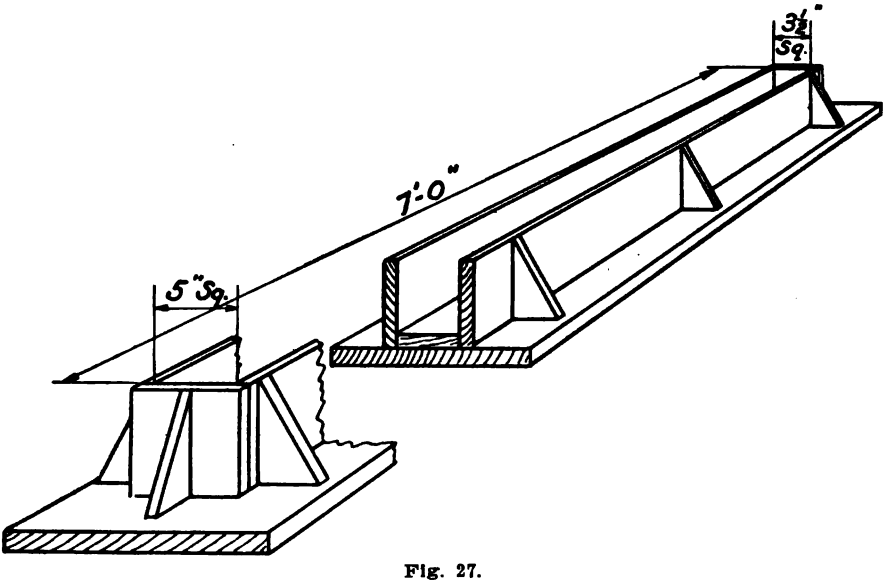


Fig. 27.

Then two reinforcing rods should be pressed into the concrete, one placed parallel with each side of the mold and about ¾ of an inch from it. More concrete should then be placed until the mold has been filled to within a half inch of the top. Then the remaining two reinforcing rods should be pressed into the concrete as the first two were placed. Additional concrete should be added until the mold has been slightly overfilled. While placing the concrete, the mold should be tapped on the sides with a light hammer to cause the concrete to settle compactly in it and to completely surround and adhere to the reinforcing. It is well to take the sharp-pointed or chisel-edged tool and work it along the edge of the wood form to release air bubbles and to force back the coarse pebbles from against the form face. This produces a smooth finish as the operation causes the sand-cement mortar to come next to the form. The excess of concrete over and above that required to fill the mold should be struck off with a straight-edged stick guided along the upper edges of the side forms and, finally, the surface should be smoothed with a wood trowel or "float" as it is called.

Forms are best left on the post for five or six days. During this time the post should be kept moist. This can be done by covering it with wet hay or straw, or wet burlap and keeping the covering wet so that moisture will not be lost from the concrete. Water is necessary to proper hardening of the concrete.

The drawing, Fig. 27, shows the various pieces of which the form is composed. For durability, the support or bottom of the form may well be of 1¼-inch stuff. At the center, and tapered to conform to the taper of the post, there should be nailed a 1-inch strip. The sides are shaped like this strip but 1 inch wider. They are set up against it, held in position by the blocks and the ends of the form are closed by blocks that may be clamped into position with wood or metal clamps.

It requires but little ingenuity to vary the plain, simple concrete post described so that it becomes one having almost any degree of ornament desired. For example, the post may be made a little larger and will serve well as a hitching post. Wood letters can be cut out and attached to the bottom of the mold so that a name can be cast in the concrete, if desired. Beveled strips placed in the corner of the mold make the shape of the finished post more attractive by remov-

Quantities of Sand and Gravel or Stone Required for a One-Bag Batch of Mortar or Concrete and Volume of Resulting Compacted Mortar or Concrete

MIXTURES			MATERIALS			VOLUME IN CU. FT.	
Cement	Sand	Gravel or Stone	Cement in Sacks	Sand Cu. Ft.	Gravel or Stone Cu. Ft.	Mortar	Concrete
1	1.5		1	1.5		1.75	
1	2		1	2.0		2.1	
1	3		1	3.0		2.8	
1	1.5	3	1	1.5	3		3.5
1	2	3	1	2	3		3.9
1	2	4	1	2	4		4.5
1	2.5	4	1	2.5	4		4.8
1	2.5	5	1	2.5	5		5.4
1	3	5	1	3	5		5.8

Quantities of Cement, Sand and Gravel or Stone Required for One Cubic Yard of Compacted Mortar or Concrete

MIXTURES				QUANTITIES OF MATERIALS			
				Sand		Stone or Gravel	
Cement	Sand	Gravel or Stone	Cement in Sacks	Cu. Ft.	Cu. Yd.	Cu. Ft.	Cu. Yd.
1	1.5		15.5	23.2	.86		
1	2		12.8	25.6	.95		
1	3		9.6	28.8	1.07		
1	1.5	3	7.6	11.4	.42	22.8	.84
1	2	3	7.0	14.0	.52	21.0	.78
1	2	4	6.0	12.0	.44	24.0	.89
1	2.5	4	5.6	14.0	.52	22.4	.83
1	2.5	5	5.0	12.5	.46	25.0	.92
1	3	5	4.6	13.8	.51	23.0	.85

ing the sharp corners. By making the form still larger and having straight sides instead of tapering ones, the post can be made to have any degree of massiveness and serve for a gate post. Each change of size and intended use necessitates a change in size of reinforcing rods used. Reinforcing is necessary in concrete posts because, while concrete is very strong in compression, it is not strong in resisting bending or pulling strains. The concrete bonds with, or adheres to, the steel, and as steel is strong in tension or in resisting pulling strains, the combination of concrete and steel makes full use of the peculiar properties of both materials. Increasing the length of the form makes it possible to cast a clothes line post. The principles of the post apply with some modification to building columns. Of course, where columns are to carry a load, the concrete must be designed, as engineers say, so that it has the proper amount of reinforcing for the use to which it is to be put.

References—

Practical Concrete Work for the School and Home, by Campbell, The Prang Co., Chicago.

Farm Concrete, The Macmillan Co., New York.

Concrete Fence Posts (free bulletin), Portland Cement Association, Chicago.

CONCRETE TROUGHS *

14. Since concrete is a dense, non-absorbent material, troughs built of it can be easily kept clean and sanitary. This is very important in stock raising. Farm animals require clean drinking water just as do human beings.

The construction of the trough shown in Fig. 28 is described here. The form of this trough is such that the inside faces slant outward so that the walls are thinner at the top than at the bottom. The particular object of this feature is to provide means for relieving pressure caused by ice when water freezes. The drawing shows forms with concrete in them, part of the forms and trough being cut away to illustrate details of the work.

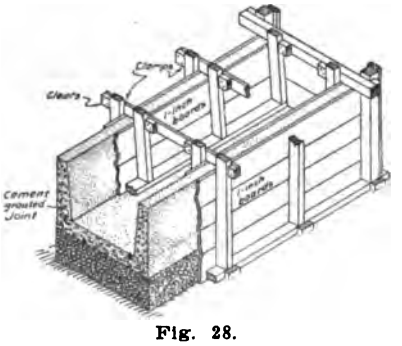


Fig. 28.

Practically the same materials are required for building a concrete trough as are required for a fence post. (Art. 13.) The kind and quantity of reinforcement will vary depending upon the size of the trough, but for small troughs, 2 by 6 feet, as shown here, ¼ inch twisted, square, steel rods will serve or woven wire fabric made especially for reinforcing concrete may be substituted.

A trough is efficient only if watertight. Two things are important to secure watertightness of a concrete trough, **properly proportioned materials,** mixed and properly placed at the right consistency, and **continuous concreting,** that is,

* By H. Colin Campbell, Director Editorial Bureau, Portland Cement Association, Chicago.

once the work has been started, it should not be stopped until the forms have been filled. This means that reinforcement and all necessary materials must be on hand before starting the work The inside form should be complete so that when the concrete has been placed for the bottom or floor of the tank the inside form can be set into position and concreting proceed with no further interruption.

A 1:2:3 mixture is required. However, if the side walls of the trough vary from 2 to 3 inches thick, the pebbles, or broken stone may range larger than ½ inch. They may be up to ¾ or even 1 inch in greatest dimension. The same methods of measuring and mixing the concrete are followed as were described for the concrete fence post. Place concrete in the forms up to about half of the intended thickness of the floor. Then set the reinforcing in shape properly assembled. If rods are used, these should have been built up in the form of a basket with the rods forming 4 to 6 inch meshes and with points of intersection, between vertical and horizontal rods, tied together with soft iron wire. Having placed this cage of reinforcement on the concrete in the bottom of the form, add enough concrete at once to bring the floor or bottom up to required thickness. Smooth off with a wood float so the surface is even and immediately place the inside form, centering it properly and securing it in the required position with clamps and braces. Begin at once to place the concrete that will form the side and end walls of the trough. Be sure to spade or puddle the concrete thoroughly in the forms while placing, particularly that concrete against the form faces, so the concrete will settle to utmost compactness and the finished surface when the work is exposed will be smooth, regular and free from pebble pockets. Fill the forms full and strike off around the top, smoothing with a wood float. Allow the forms to remain in position for at least 24 hours. When the forms have been removed, if some pebble pockets or irregular spots appear on the surface, these should at once be patched by filling with a cement-sand mortar mixed of 1 part cement to 2 parts sand. The whole surface can be gone over slightly with the wood float while wetting the surface to smooth it up and give it a finished appearance. If desired, a paint composed of cement and water mixed to about the consistency of thick cream, may be painted on, during the first 24 hours; that is, immediately after the forms are removed. Like the concrete fence post, the concrete trough should be protected for a week or ten days. If it is a small trough, it may be filled with water when 48 hours old, and this will furnish the required protection.

The principles of the concrete trough described apply to concrete flower boxes and even to concrete vases or urns, the difference between the trough and other similar objects being merely a difference in shape or wall thickness or surface ornament. The plain, simple trough described can easily be given a touch of ornamentation. One practical way is to nail thin boards on the inside face of the outside form so that depressed panels will be cast in the concrete. As the size and use of this project is varied, it is necessary that the design be so changed that sufficient steel rods or mesh will be used in the concrete to give the required tensile strength against the bursting strains to which the filled tank may be subjected. Concrete men doing job work often have special or prepared forms which they use. These forms may be made of wood or metal and are adapted to tanks, sewers, silos, culverts, etc. Concrete block men make concrete blocks in special forms of various types and sizes.

The trade use of concrete is almost as varied as that of wood and steel and it is used in construction work from plain, simple objects to decorative ornaments.

References—

Practical Concrete Work for the School and Home, by Campbell, The Prang Co., Chicago.

Farm Concrete ,by K. T. Ekblaw, The Macmillan Co., New York.

Concrete for the Farm and in the Shop, by H. Colin Campbell, Norman W. Henley Co., New York.

Concrete Troughs and Tanks (free bulletin), Portland Cement Association, Chicago.

CONCRETE WALKS *

15. The average concrete sidewalk is composed of slabs 4 feet square. The slabs are made by cutting joints across the walk at regular intervals. As a rule, it is not advisable that sidewalk slabs have a greater surface area than 36 square feet. The necessity for building walks in slabs is due to the fact that unless the stretch of concrete is broken by joints made in it, the walk will eventually crack from expansion and contraction caused by temperature changes.

If walks have been properly jointed, if the foundation, concrete mixtures, workmanship and other details have been correct, they will not crack. The many cracked sidewalks found are usually due to thin slabs, poor foundations, poor drainage beneath the walks, and mixtures weak or lean in cement.

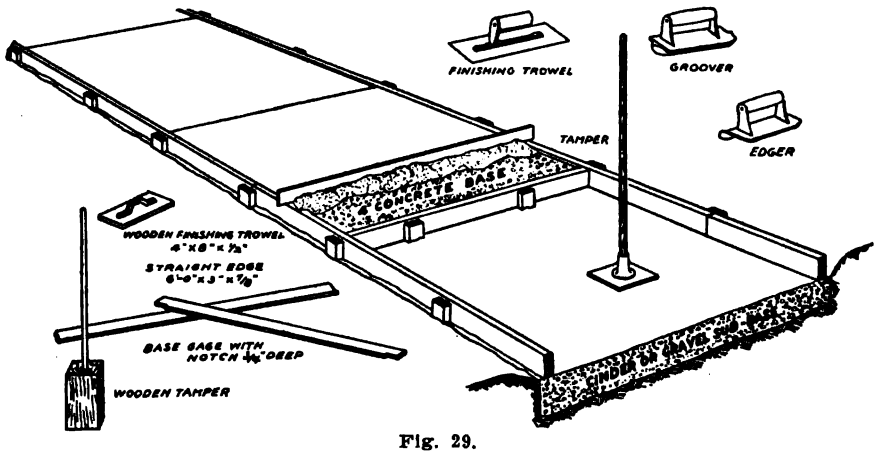


Fig. 29.

Materials required for concrete walk construction are the same as for the concrete post. (Art. 13.) In addition to the tools used in making a concrete post, a straight edge and tamper are needed.

Fig. 29 shows a layout for concrete walk construction. Side forms are first staked in place. These should be 2x4's set on edge and staked to line and grade so that they will not bulge out of place while the concrete is being tamped.

* By H. Colin Campbell, Director Editorial Bureau, Portland Cement Association, Chicago.

All loose earth, vegetation and soft spots must be dug out and the area on which the walk is to be laid thoroughly compacted by tamping. If the soil where the concrete is to be placed is of a nature that drains readily and thoroughly after rains, no sub-base will be necessary. If, however, the ground is of a nature that retains water, it is usually advisable to dig out the area and make a 6 or 8-inch fill of clean gravel or cinders, compacting this thoroughly and using it as a foundation for the concrete. Lengths of tile should be connected to this foundation or sub-base at sufficiently frequent intervals and lead to free outlets so that water will be conducted from beneath the pavement. If this is not done, the foundation merely becomes a sump or water hole to collect and retain water. Having prepared the foundation and set up side forms, the next thing to do is to set cross forms at intervals corresponding to the length of slabs.

Concrete walks are either of one or two-course construction. Two-course construction means that a leaner concrete, such as 1:3:5 or a 1:2½:4 mixture may be used for the base and the finished surface consists of a ½ or ¾ inch layer of rich sand-cement mortar, such as a 1:2 mixture. It is best to use one-course construction, which means that the same mixture, preferably a 1:2:3, is used throughout and placed at one operation. One advantage of one-course construction is that there is no trouble like separation of top course and base, as often happens due to poor workmanship when two-course construction is used.

The concrete should be mixed to a jelly-like consistency as in making the concrete post. (Art. 13.) It should be placed in the forms, lightly tamped and spaded into place, then struck off by running the straightedge along the top of forms to remove concrete in excess of that required to fill them. Finishing should be done by using a wood float, smoothing the surface firmly but not excessively, as overtroweling brings too much fine cement to the surface and makes it less wear-resisting. In placing the concrete, forms for alternate slabs are filled first. When these slabs have hardened sufficiently to permit removing the cross pieces, concrete is placed for the remaining slabs. Finishing tools known as groovers and edgers are used to properly finish joints between slabs and to give a neat, rounded corner to the outer edges of the walk.

One of the most important details of walk construction is to protect them against too rapid drying out. From the nature of the work, a large surface area is exposed to the air. Sun and drying wind will spoil the best of concrete, if left unprotected, until it has hardened enough to be proof against the action of drying influences. Immediately after the concrete has hardened so that a covering of moist earth would not mar the surface, two inches at least of such a covering should be applied and this should be kept in place and moist for a week to permit the concrete to harden properly.

In part, the principles of the concrete walk have many extensions of application. A series of walks laid side by side form a floor. If one of the slabs were set on edge, we would have a section of a wall. However, walks are usually made 4 to 5 inches thick and most walls, even in small buildings, are 6 or 8 inches thick. Still, the principle of construction is similar with the exception that in walls, it is usually necessary to insert reinforcing steel in the form of rods or mesh, because walls are subjected to different loads and stresses than must be met by floors and walks laid on the ground. The concrete highway pavement may be regarded as another extension of the concrete walk.

References—

Practical Concrete Work for the School and Home, by Campbell, The Prang Co., Chicago.

Concrete Feeding Floors, Barnyard Pavements and Concrete Walks (free pamphlet), Portland Cement Association, Chicago.

Suggested Specifications for Concrete Walks (free leaflets), Portland Cement Association, Chicago.

CONCRETE STEPS *

16. Where necessary to pass from one level to another, as to go from ground level into a basement or cellar, or from ground level up into the first story of a house or other structure, steps are used.

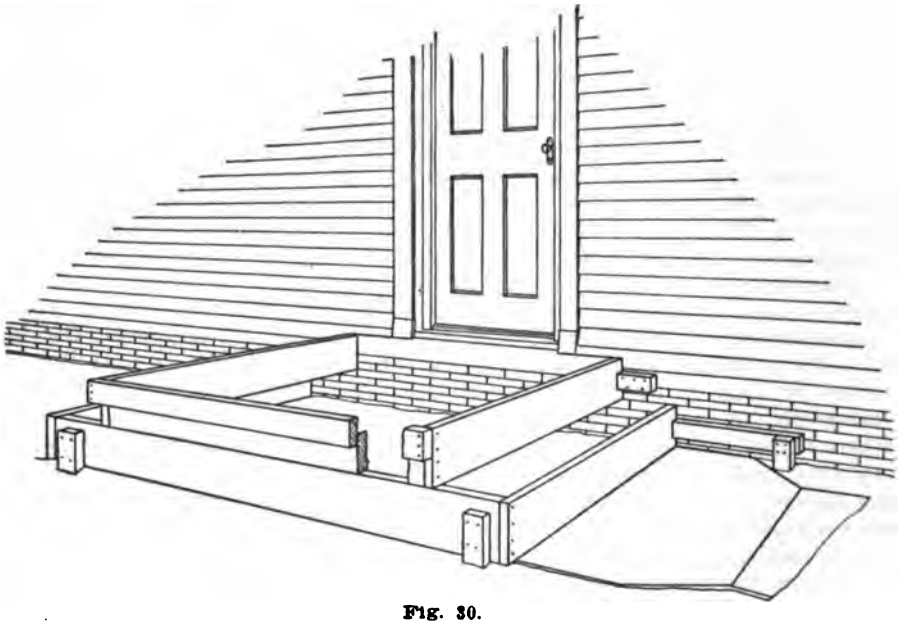


Fig. 30.

The accompanying drawing (Fig. 30) shows form for simple steps that may be readily adapted to many places as, for example, a side entranceway of a house. The dimensions will be governed by the width of doorway and the height. As a rule, the rise and tread of a step are more or less fixed for ease of ascent. The rise is generally from 6 to 7 inches for each step and the tread is from 8 to 10 inches. The materials required for constructing simple steps like those illustrated are the same as needed for other concrete projects in this section. One-inch lumber will be suitable for forms.

Before commencing the work of placing concrete, it is necessary to dig out the area where the steps are to be placed, removing all vegetable matter, grass, roots and similar refuse. If the ground is not firm, it should be well compacted by sprinkling with water and tamping. Then a layer of clean cinders or gravel should be laid. The last is for the purpose of providing free drainage beneath the concrete, thus preventing water from being retained and causing upheaval from freezing. Form lumber should be cut and staked into place as

* By H. Colin Campbell, Director Editorial Bureau, Portland Cement Association, Chicago.

shown in the sketch. Pieces should be nailed lightly together so that taking down the forms will not require hammering that will injure the concrete before it has hardened. The concrete should be mixed in the proportions 1:2:4, using clean, well graded materials as described under Art. 208, Sec. 4.

The aggregates, pebbles or broken stone, may range in size up to 1½", since there is considerable mass and the construction permits the use of the larger sized particles. After properly measuring out the required quantity of the materials as determined by computing the volume of the steps to be built, they are mixed as already described under other concrete projects. There should be just enough water added when mixing so that when the concrete is placed in the forms and firmly tamped to compact it, free water will flush to the surface under the tamper. Forms should be filled to within ¼ or ¾ of an inch of the top of each section of each step. When thus filld, the remainder of the space should be filled with a 1:2 cement-sand mortar mixed to a stiff consistency so that it is somewhat difficult to work under a trowel.

Twenty-four hours after the last concrete is placed, forms may be removed. Then any imperfections or pockets on the surface may be pointed or plastered up with a 1:2 cement-sand mortar. The surface of the concrete should be slightly brushed and wet down immediately before applying this mortar. The work should be kept covered for several days so the concrete will not dry out too rapidly.

Variations in the finished appearance of concrete steps can be produced by very slight modifications of the forms. The section or board which forms the riser face can be built out slightly at the top so that a square or rounded edge, as may be desired, will be formed as a nose to the tread. When this is done, it is usually necessary to embed a layer of wire mesh fabric in the tread while placing the mortar to prevent the nosing from being broken off in use.

A modification of the concrete steps might be used for a horse block. Also, being massive, the steps have some of the elements of concrete foundations. A little thought will suggest extensions of the application of the principles which are involved in constructing concrete steps.

WIRING FOR AN ELECTRIC IRON*

17. The common method of connecting an electric flatiron is by attaching the flatiron cord to a light drop cord. Occasionally, a person using the electric iron so connected will forget to disconnect it and the result is an over-heated iron or a burned garment. A safer and more convenient method is to install a wall receptacle as illustrated in Fig. 31. This has a signal attachment plug (B), a socket (D) for making connection to the iron, and push buttons (E) to turn current on and off. The wall receptacle may be placed in any room, at any convenient height from the floor, and on any wall.

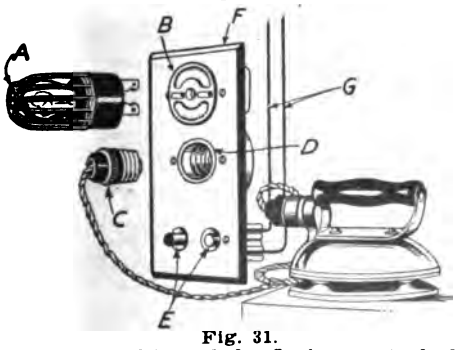


Fig. 31.

The position of the flush receptacle both with reference to height from floor

* By H. F. Good, Instructor of Gas Engineering, Stout Institute, Menomonie, Wis.

and location of ironing board, the type of flush receptacle, and the length of cord, etc. must be taken into consideration.

Make suitable drawing of the project showing the position of the flush receptacle in the room and all dimensions necessary. Also make bill of material. For flatiron circuit, it is best to use No. 12 wire. Standard flatiron cord of any desired length may be attached to the attachment plug as shown in C, Fig. 31. Procure all necessary fixtures, wire, cleats, flexible tubing, etc. before starting the work.

After deciding where flush receptacle is to be placed, make an opening in the wall, being careful not to make the opening too large nor to break plaster around the opening. Locate main light circuit in ceiling or basement, whichever is most convenient, and then by means of a fish wire, draw the No. 12 wire into place. Connect up to the light circuit, being sure to solder and tape all joints and so manage the wire that no short circuit is made. Also, where necessary, use flexible tubing to cover wires crossing each other or coming in contact with any object. Such matters as cutting openings in floors to get at main light circuit, notching joists, or locating cleats, must be worked out as each particular project demands.

Special attention should be given to making of tight connections and neatness in installing all parts.

A flush receptacle such as mentioned in this project may be used conveniently with such appliances as fans, toasters, coffee percolators, heating pads, sewing machine motors, portable lamps, etc.

This project provides one of the small conveniences such as a man in the inside-wiring business might have to install. Electric wiring, of which there are a number of different branches, is only one of the many lines of work in the electrical industry. Electricity is such an important factor in our every-day life and there are so many opportunities in electrical lines that any one with ability or inclination bearing on this work should carefully consider the many phases of the industry.

References—

Croft's Library of Practical Electricity, by Terrell Croft, McGraw-Hill Book Co., New York.

Standard Hand-Book for Electrical Engineers, McGraw-Hill Book Co., New York.

"The National Code" for Electric Wiring and Apparatus, National Board of Fire Underwriters, New York.

TYPICAL DOOR CONSTRUCTION *

18. Doors are used so often that ignorance of their construction is inexcusable. The purpose of this article is to present typical door construction.

The drawings are dimensioned sufficiently to show proportions, sizes of materials, joints, etc.

The materials used should, of course, be suitable for the particular purpose for which the door is intended. Panels should be selected with a view of using stock widths of lumber.

The purpose for which the door is intended usually determines the kind of material to be used, the size, the panel arrangement, the finish, etc. Note the

* By J. J. Ritter, Director of Industrial Work, Ft. Wayne, Ind.

various types of doors shown. It is not difficult to identify these types in connection with cabinets, lockers, book cases, and houses.

A working drawing should be made; either make the assembled drawing a complete working drawing or make detailed working drawings of each piece.

The construction of the door is evident. It requires stock planed to dimensions. Joint construction of one kind or another is always necessary and, in many doors, panels are used. The door shown in Fig. 32 with the lock rail is a typical cupboard door. Note, by observation, that doors commonly used in homes have the lock rail below the middle point and of about the same width as the bottom rail.

Many doors are now made with large single panels; some are "built up"

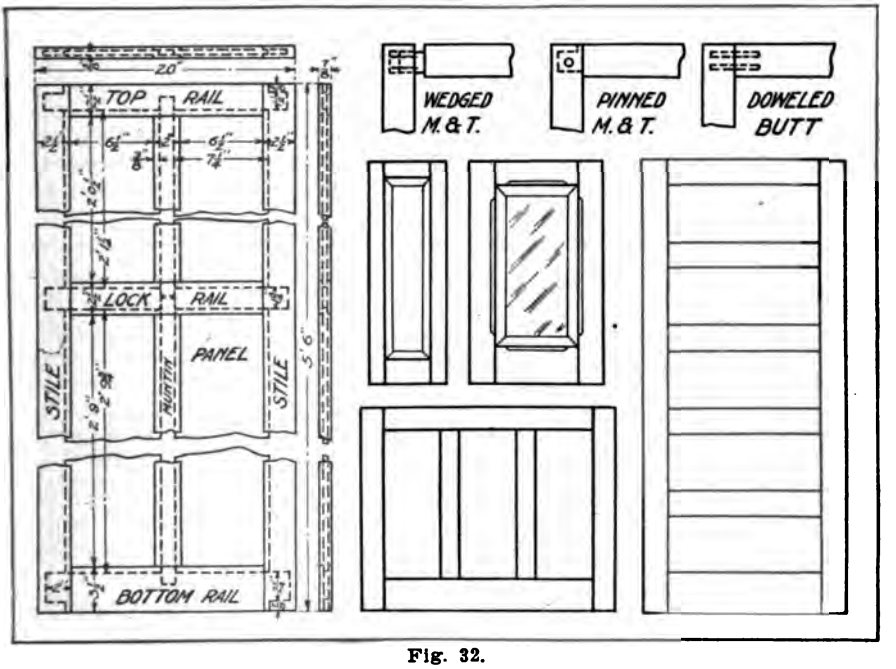


Fig. 32.

with soft wood cores and veneers of selected materials, showing merely a plain surface on either side.

In assembling a door, be sure that all parts fit properly and have clamps, glue, and other necessary materials ready for assembling without delay. Bear in mind that the grooves into which the panels fit should be slightly deeper than the necessary allowance for the panels. This permits expansion of panels. Do not glue the panels in place, as this is not only unnecessary, but unwise.

The finish may be filler and varnish, filler and wax, stain and wax, etc., depending upon the finish desired. Possibly the door is to be used in connection with a cabinet, book case, or any one of several articles of furniture. In that case the finish of the door should be in harmony with the finish of the entire problem.

Every door offers a problem for design; and the student has opportunity for originality in the designing of any door for a definite purpose.

Doors are being manufactured daily. The planing mill, cabinet shop and furniture factory make doors of all kinds. The carpenter is often called upon to construct doors. In industry, they are almost entirely made by machinery, involving several processes. Made by hand, they involve many operations with which the student is familiar, such as planing, sawing, boring, chiseling, sand papering, and finishing.

References—

Essentials of Woodworking, by S. L. Griffith, The Manual Arts Press, Peoria, Ill.

Handwork in Wood, by William Noyes, The Manual Arts Press, Peoria, Ill.

Bench Work in Wood, by Goss, Ginn & Co., Boston.

Exercises in Woodworking, by Sickels, American Book Co., New York.

TYPICAL DRAWER CONSTRUCTION *

19. Cabinets, desks, tables, and in fact, practically all cabinet problems embody drawers in their construction. The typical examples herewith presented are intended to show good drawer construction.

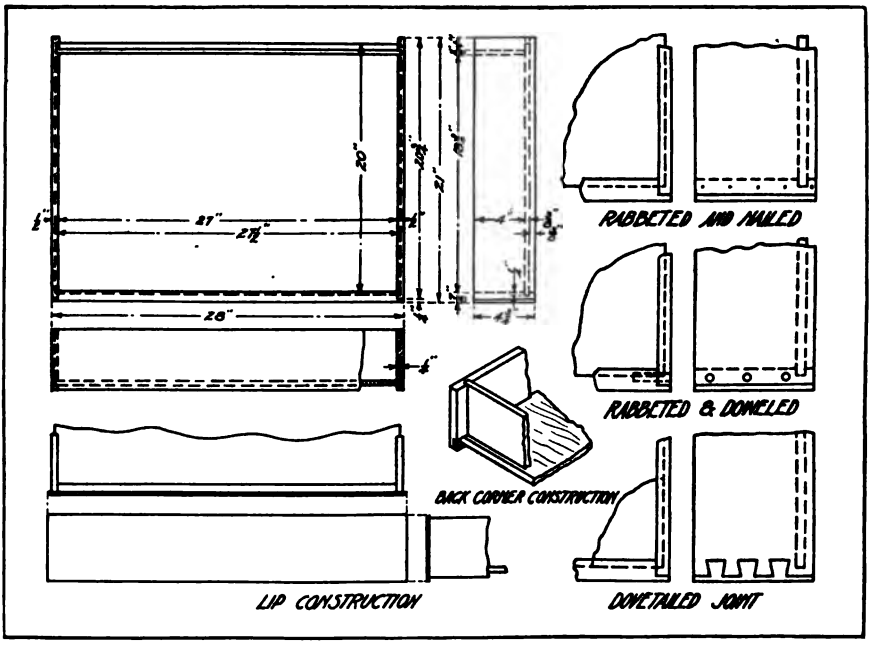


Fig. 33.

The dimensions given on the drawing (Fig. 33) are for a typical library table drawer.

The front of the drawer should be of the same material as the table, cabinet,

* By J. J. Ritter, Director of Industrial Work, Ft. Wayne, Ind.

or desk, for which it is intended. The sides, back and bottom may be of any suitable material, such as pine, poplar, or maple. In high class furniture, the drawers are often made throughout of the same material as the piece of furniture.

The drawer should be designed as a part of the whole problem of which it is a part. It is usually one detail of a larger project.

A complete working drawing should be made showing all details of construction, and dimensions of the various parts.

The drawings show types of construction suitable for drawers. The dovetail construction for the sides and front is the type used in the highest grade of furniture.

The plan of permitting the bottom board to extend beyond the back board, but not to the ends of the side pieces, is desirable because of the shrinkage and expansion of the bottom board. Note that all drawers, except very narrow ones, should have the direction of the grain in the bottom board from side to side, not from front to back. See isometric drawing of back corner of drawer. This permits the shrinkage and expansion mentioned above.

By gluing the bottom board to the front piece into which it is set, the continual gap between the front and bottom pieces so often found in drawers is eliminated.

Three-ply material is frequently used for bottom boards of drawers in the better grades of furniture.

The back corners may be dovetailed, if desired.

The bottom board may be set into the back board, in which case the securing of the bottom board to the sides at the middle would permit shrinkage and expansion in both directions, provided the grooves in the front and the back pieces were cut deep enough.

If all parts fit properly, there is no great difficulty in assembling a drawer. The student should be sure that the drawer "squares up," for it must fit into its place in the project.

The finish of the front of the drawer should, of course, be similar to the remainder of the project of which it is only a part. Sometimes no finish is required except on the front piece although many drawers are finished all over. The sides should be perfectly smooth, on the outside and bottom edges. The entire drawer should be clean and sanded, and, if finished, either varnished the natural color with the exception of the front, or stained the color of the remainder of the project and varnished.

The type of construction at the front corners, the lip, the handle or knob, and the partitioning offer opportunity for variation and originality.

Many familiar operations present themselves in the construction of a drawer, such as planing, sawing, chiseling, and finishing. These are typical and fundamental processes in cabinet work and are used daily by cabinet makers and furniture manufacturers.

References—

Essentials of Woodworking, by S. L. Griffith, The Manual Arts Press, Peoria, Ill.

Handwork in Wood, by William Noyes, The Manual Arts Press, Peoria, Ill. Peoria, Ill.

Shopwork, by Rusch and Conway, Industrial Book & Equipment Co., Indianapolis.

Exercises in Woodworking, by Sickels, American Book Co., New York.

UPHOLSTERING *

20. A large per cent of the furniture manufactured today is upholstered, both for the purpose of comfort and for artistic effect. For information in purchasing furniture and knowledge of methods employed in upholstering, it is important that this phase of furniture manufacturing be studied. The problem of upholstering a piece of furniture may be undertaken in the construction of the foot stool shown in Fig. 34.

The general dimensions of the foot stool are indicated on the drawing except the height, which has purposely been omitted as it should be determined by the place for which the stool is designed. The dimensions given may be modified to suit the ideas of the workman.

Various materials are needed in the construction of this problem. For the legs and rails, oak, walnut or other hard wood should be used, and some soft

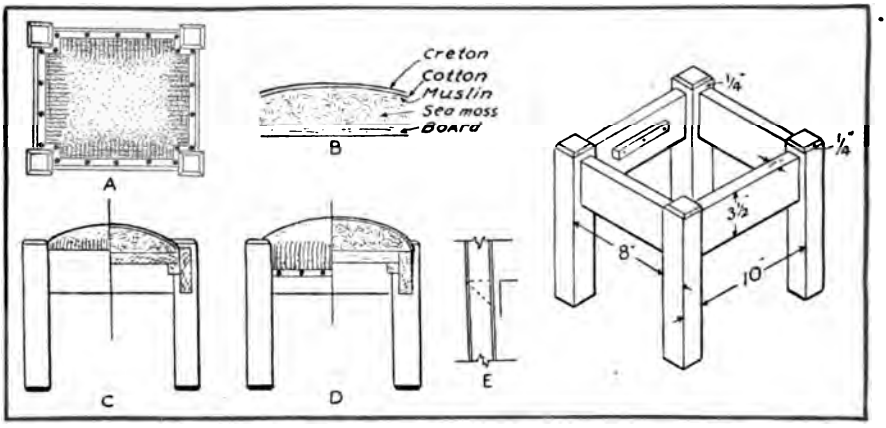


Fig. 34.

wood such as white pine for the top and cleats. Instead of a wooden top, a webbing may be used. In upholstering, sea moss or curled hair may be used for the packing, cotton or jute for the padding, unbleached muslin or canvas for the binding, leather, imitation leather, cretonne or tapestry for the covering, and tape, gimp and upholstering tacks for finishing.

In planning the foot stool, the place where it is to be used and the weight and wear it will have to stand are factors in determining the size and materials to use. The color of the top, woodwork, gimp and upholstering tacks should harmonize. The upholstering may be designed to extend over on the rails, or side pieces as shown at A, Fig. 34; it may extend down on the inside of the side pieces as in C, or it may extend down the outside of the side pieces as in D. The cushion may be made high and rounding or low and flat. The joints may be doweled as shown, or mortised.

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*By H. H. Harrison, Director of Industrial Work, Marshall, Mich.

After all points covering the construction of the project have been determined, a detailed working drawing should be made. A working drawing of the upholstering would be difficult to make and a sketch may be used. The sketch should show all dimensions not shown on the working drawing of the woodwork.

All dimensions in the illustration, Fig. 34, show finished sizes. The stock for the legs should be squared up in one piece and cut to the finished lengths afterward, as should also the material for the sides.

Note that the top of the legs are beveled. The dowels which fasten the stool together are placed two in each end of the rails, each thee-fourths of an inch from the edges. The dowels are 3″ long with one and one-half inches extending from the side rails into the legs. In A and D, Fig. 34, the bottom board should fit tightly while in C the board should have an allowance of ½″ on all four sides to leave room for the muslin, covering, and tacks. The top will require about one-half pound of sea moss. The cotton padding should be cut to the exact size of the finished top, while the muslin binding and top covering should be left at least 2″ larger on all sides than the top.

In assembling, the pieces should be glued and clamped together and left for the glue to set. The woodwork should next be cleaned and smoothed and finally finished with stain and varnish. If webbing is used in the bottom instead of a board, it should be tacked in place. In upholstering the stool, the sea moss is formed as much as possible into a cushion and placed on the top to be covered. The muslin binding should be placed over it and tacked down carefully. It should be first tacked only temporarily from corner to corner and then stretched from center to center of both sides. It should be tacked securely at the center and tacked down firmly all along the edges, working from the center of each side towards the corners and removing the temporary tacks as the permanent ones are placed. A layer of cotton is placed over the muslin and then the top cover placed, much after the manner in which the muslin was placed. Gimp and ornamental tacks are used as shown in Fig. 34, but the corner is first fastened with ordinary 2 or 3 oz. tacks. The gimp is placed over the rough edge to hide it and ornamental tacks are used for decoration.

This is only one of many methods of upholstering but it may be applied to other problems besides foot stools, as upholstered chairs, window seats, etc. Automobile seats, car seats, and furniture, are usually upholstered in some form or another. On account of the different methods of upholstering and applications of it, those working on car seats, automobile cushions, and furniture are classed separately, and these in turn divided into groups. Each follows special processes required by the trade but the general principles of all the work are the same. Along with actual upholstering, it would be well to become better acquainted with the harmonizing of colors, the values of the materials used and the difference between good and bad proportions.

References—

Shopwork, by Rusch and Conway, Industrial Book & Equipment Co., Indianapolis.

Shop Projects Based on Community Problems, by M. G. Burton, Ginn & Co., Boston.

Upholstery, by P. N. Hasluck, David McKay, Philadelphia.

Furniture Upholstering, by J. W. Stephenson, Clifford and Lawton, New York.

PIPE COUPLING*

21. When a steam plant, or water system is installed in a building, couplings are used for joining most of the lengths of pipe. Couplings are of two general kinds, those having **righthand** threads tapped in **both** ends, and those having a **right hand** thread in **one** end and a **left hand** thread in **the other.** The latter is called a right and left coupling and is distinguished by a series of ridges cast on it when made. The processes of making either coupling are practically the same and the two chief tasks are making the pattern and molding the coupling.

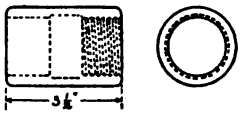

Fig. 35—Pipe coupling.

Fig. 36 shows a completed pattern for a pipe coupling. Notice the difference in the shape of the pattern compared with the finished coupling (Fig. 35). The pattern must be made with a core-print on each end for the purpose of forming recesses in the sand of the mold. After the pattern is pulled from the mold, the core is placed in these recesses or prints.

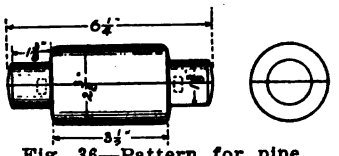

Fig. 36—Pattern for pipe coupling.

To make the pattern, two pieces of wood about 1⅝"x2¾"x8" will be required. As this is to be a parted pattern, the two pieces must be planed on one surface so as to fit together accurately. Pattern pins must be inserted as shown in Fig. 36. The pieces are then fastened together by putting a screw at each end, or by pinch dogs, or by gluing for about ½" at each end. The pattern may next be planed to circular form or turned to shape. If a lathe is not available, the core prints may be formed by using a back-saw with a depth gauge attached to cut to proper depths at ends of pattern. The surplus stock may be removed with a sharp chisel. However, it can be shaped much more quickly, if a lathe is used.

The construction of the core-box in which the core for the coupling is made completes the woodworking operations. The core-box consists of five pieces of wood as shown in Fig. 37, two of which will have a semi-circular groove throughout their length of the same diameter as the end of the pattern which forms the coreprint. The center piece has a little larger groove than the two adjacent pieces as shown in Fig. 37. The end pieces are nailed on as shown and allowance for draft cut out with a knife. When the pattern is completed, the next process is that of molding.

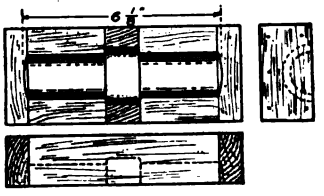

Fig. 37—Corebox for pipe coupling.

In general, any pattern is made in a similar manner to the above. Patterns may be made of only one piece, or for complex castings, a number of pieces may be required, the entire pattern being fitted together. The pattern for a Pipe Tee shown in Fig. 39 is similar to that of the coupling and presents an excellent problem. It is, however, much more difficult to make. A lathe is almost necessary for making this

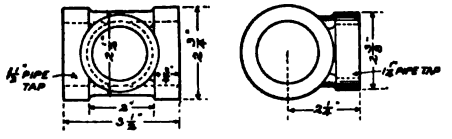

Fig. 38—Pipe tee.

* By H. T. Purfield, Instructor of Pattern-making and Foundry Work, Ft. Wayne, Indiana.

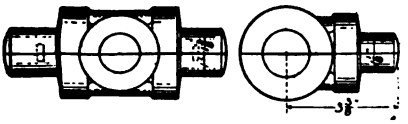

Fig. 39—Pattern for pipe tee.

pattern. The body of the tee and the branch are fitted together after being made. Fillets or rounded internal angles are introduced so that there will be no sharp corners in which the sand might stick when molding the pattern. The core-box is also more complicated, as it must be made so that the core will fit all the core prints if the mold made by the prints on the pattern.

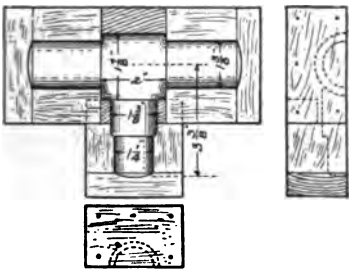

Fig. 40—Corebox for pipe tee.

The direction of the grain of the wood in the several pieces for this core-box and methods of construction are indicated in Fig. 40. The coupling and pipe tee belong to a large class of castings known as pipe fittings. Other problems in this line are elbows, nipples, etc. Patterns for each present special problems in construction. These projects will serve to lead into others as the work of the patternmaker is varied with the numerous shapes and sizes of patterns he is required to make.

22. Molding.—To mold the coupling, place the half-pattern without pins on the molding board flat side down, ram up the nowel (drag), strike off, vent and roll over. Make the parting smooth and hard with a trowel, sprinkle on parting sand, and place the other half of the pattern in position as determined by the pins. Set on cope and see that cope and nowel fit. Set sprue pin or gate stick in position and ram up cope. Vent and form a pouring basin around the upper end of sprue. The cope is now ready to be lifted, which must be done carefully and steadily as any extra jar may cause the sand to fall out.

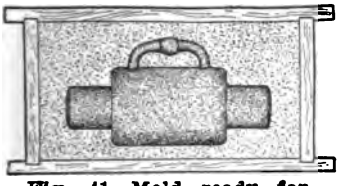

Fig. 41—Mold ready for placing core.

Set the cope down on one side, set a board up against its upper surface and gently lay both down. Swab and draw the pattern; cut gates in nowel (no gates are required in cope); close and clamp the mold. It is now ready to be poured (filled) with molten metal. After the metal cools, the casting may be taken from the mold, machined, threaded, and is then ready for use. The pipe tee shown in Fig. 38 is molded in the same manner as the coupling.

References—

Wood Patternmaking, by Purfield, The Manual Arts Press, Peoria, Ill.
Moulder's Text-Book, by West, Jno. Wiley & Sons, New York.
Woodwork for Secondary Schools, by Griffith, The Manual Arts Press, Peoria, Ill.

SOLDERS AND SOLDERING*

23. Soldering is the art of joining or uniting pieces of metal by fusing or melting into the joint a metal or alloy which melts at a lower temperature than the pieces being joined. The metal added is known as solder, which is made of a

* By Edward E. Greene, Instructor of Sheet Metal Work, Arsenal Technical Schools, Indianapolis, Indiana.

combination of metals, such as lead, tin, and bismuth. For ordinary light soldering, an alloy of one-half lead and one-half tin is satisfactory. In this type of soldering, the heat is supplied to the alloy and directly to the joint by means of soldering coppers.

There is present at all times on the surface of metals what is known as metalic oxide, which must be removed before the solder will stick. More oxide quickly forms when heat is applied. To dissolve that already formed on the metal and to prevent more from forming during the soldering process, a mixture known as flux must be applied. The most commonly used flux is one easily prepared by dissolving zinc in muriatic acid. It is used in its raw state to solder galvanized iron and zinc. For brass, copper, and tinplate, as much zinc as the acid will dissolve must be added, after which the flux is known as zinc chloride, or "cut acid." For soldering new, clean metal, it may be diluted with as much water as possible and still do the work. Rosin is used extensively as a flux for soldering tinplate, lead, new brass, and bright copper.

The soldering copper also needs preparation. It must be filed to a clean, smooth surface and "tinned," a procedure accomplished, after the copper is heated to the proper temperature, by rubbing it on a block of salammoniac. Solder is then applied to the surface of the copper.

The following four points must be kept in mind when soldering:

1. A perfectly clean joint or surface must be obtained either by scraping, filing, or cleaning with raw acid.
2. A clean, smooth, well tinned copper of proper shape is necessary.
3. The proper flux must be used.
4. The metal being soldered must be heated to a temperature above the melting point of the solder.

Repair Work

In repairing holes in tin pans, galvanized pails, copper and tin wash boilers, special attention must be given to cleaning the surface around the hole. Cut acid should be used on all but galvanized surfaces. Raw acid may be used to assist in the cleaning, but it should be thoroughly washed off with cold water before soldering, since otherwise it would cause corrosion. Some cases require a patch over the hole, which instances demand particular attention.

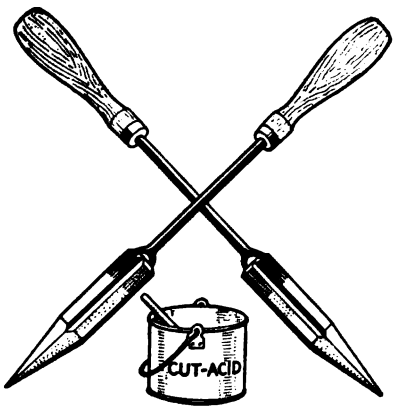

Fig. 42.

After the surface is cleaned, the flux is applied and the bright spot well tinned with soldering copper. An essential detail is to tin the surface thoroughly before piling on the solder. Many apparently good repair jobs are poor, because this point has been neglected.

The illustration shows the shape to which soldering coppers are drawn for ordinary work. For soldering the bottom seam in tanks and pails, a more convenient shape is one similar to that of a cold chisel with a blunt end about ¼ inch wide. A copper tinned on one surface only will be found better adapted to soldering upright or vertical seams, as solder does not flow freely

on untinned surfaces. The tinned side should be on top when using. Then, the solder can be easily applied and will flow to the metal being soldered and not drip off the sides of the iron.

Construction Work

The following project—a flour or sugar scoop—will afford good practice in soldering. If constructed to the dimensions given, the scoop will be a convenient size for use in the pantry.

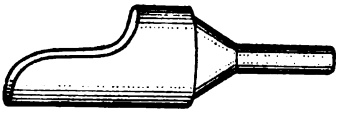

Fig. 43.

The pattern may be laid out directly on the metal, or on paper and transferred to the metal. The body, A, in Fig. 44, is developed by parallel lines. First, draw side view and profile in proper positions, then divide profile, marked "half section," into a number of equal spaces as shown by numbers, 1 to 7. From these points draw the horizontal lines intersecting the curved mouth of the scoop. In line with the back, draw the line 1′-1′. Place the stretchout on this line of twice the number of spaces contained in the half profile. Number them to correspond with numbers in the profile. From these points on the stretchout line, draw horizontal lines intersecting lines drawn from points of the same number on the curved line of the scoop. Trace a line connecting all points thus obtained. The result will be the outline or pattern for part A. The width of the pattern for the handle C may be obtained by multiplying the diameter given by 3.1416. The length is shown in the drawing. A pattern for the piece B, which is known as a conical boss, is developed by drawing the side view bced and continuing the side lines until they intersect at point a. With the distance ab as a radius, on the line a′b′ scribe the arc b′c′ 3.1416 times as long as bc. From point c′, draw a line to the center a′. Set the compass again on the point a′ and scribe the arc d′e′, thus finishing the pattern for the part B. Allowances must be made for soldering laps as shown by the side lines.

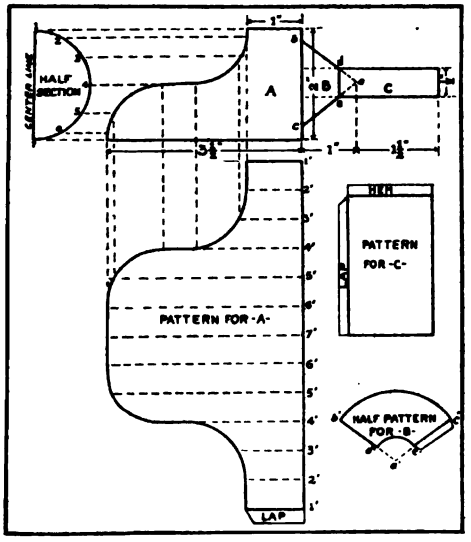

Fig. 44.

The patterns developed are now cut out. The parts should be formed as nearly as possible to their correct shape, thus making it easier to hold during the soldering. As the scoop is made of bright tinplate, either a weak solution of cut acid or rosin may be used as flux. Since the metal is thin, the soldering copper need not be very hot. The essential idea is to keep clearly in mind the four fundamental principles of soldering as given above. A circular disc, the diameter of the back of the scoop, must be cut out and soldered flush with the edge. This forms the back to which the boss is soldered. Solder the seam in the handle, part C, and attach the handle to the boss. The latter operation completes the scoop.

Tinplate is sheet iron or steel over the surface of which has been flowed a thin coating of tin. Care must be taken when soldering it, to avoid burning this tin coating, for with the tin destroyed the sheet has very little rust resisting quality. Also, it spoils the appearance of the job and makes it more difficult to solder. Tallow and rosin are good fluxes to use on new tinplate as they do not cause corrosion nor discolor the surface. In repair work, the problem is somewhat different, as generally the tinning around the hole or break has been destroyed. In this case the base metal has to be soldered and requires a different flux. Particular attention should be given to cleaning the spot or seam. All the rust must be removed and the surface scraped perfectly bright, after which the flux (cut acid in this case) is applied. The soldering can then be done with a moderately hot copper.

Copper is one of the easiest metals to solder and a very strong, neat job can be made, if care is taken to see that the surface is well cleaned before soldering. Raw muriatic acid may be used to clean it, but should be washed off before soldering, to avoid corrosion. If the acid does not clean it thoroughly, the place should be scraped well until a bright surface is obtained. Cut acid is used as flux. A hot iron is necessary, as the heat radiates quickly through the whole body of the article.

Brass is much like copper under the soldering iron and a good job can be done after a little practice. It may be cleaned in the same manner as copper. However, the cut acid may be diluted with water in most cases to about one-half strength. The heat of the soldering iron will vary with the weight of the object being soldered.

Zinc takes solder well, but melts at a lower temperature and is difficult to handle as there is danger of the soldering copper melting through it. New zinc is easily soldered with a flux of raw muriatic acid, however care should be exercised not to put on too much. It should be thoroughly washed after soldering. The copper should be hot and handled carefully. Old zinc requires the same flux, but must be scraped well before soldering.

Galvanized iron is sheet steel or iron coated with zinc. It solders similar to zinc, but does not make such a neat job. When new, a flux of raw acid is generally used, however a full strength solution of cut acid may be used when the surface is bright and not discolored from having been wet. In repair work, the nature of the soldering is similar to tinplate. The surface coating having been destroyed, the base metal has to be soldered and a flux of cut acid should be used after the joint is thoroughly cleaned.

Black iron and steel will solder easily, if first cleaned with nitric acid, washed well, and a flux of cut muriatic acid used.

The following elementary projects will afford good soldering practice: Pencil box, savings bank, mail box, measures, match safe, fruit can filler, funnel, tin cup, sprinkling can, tool chest, candle stick, and sink strainer. They can be made of tinplate, light galvanized iron, black iron, copper or brass, to give the necessary variety.

References—

Sheet Metal Work, by Neubecker, American Technical Society, Chicago.
Soldering, Brazing and Welding, by Jones, Funk & Wagnalls Co., New York.
Sheet Metal Workers' Manual, by Broemel, Frederick J. Drake & Co., Chicago.

PINT TIN CUP *

24. For many years tinplate was the only kind of sheet metal used for kitchen utensils that could be sold at a reasonable price. Aluminum did not become common until within the past twenty years and is still more costly than tinplate. Now, vessels, such as cups, are made of several materials and may be had in glass, enameled ware, china ware, and aluminum. For common use and for construction in a school shop, the cup is still best made of tin.

Cups are usually made to hold any desired quantity from less than one-half pint to a quart of liquid, but often no attention is paid to the exact capacity. Usually the height is somewhat less than the diameter, but the proportions are

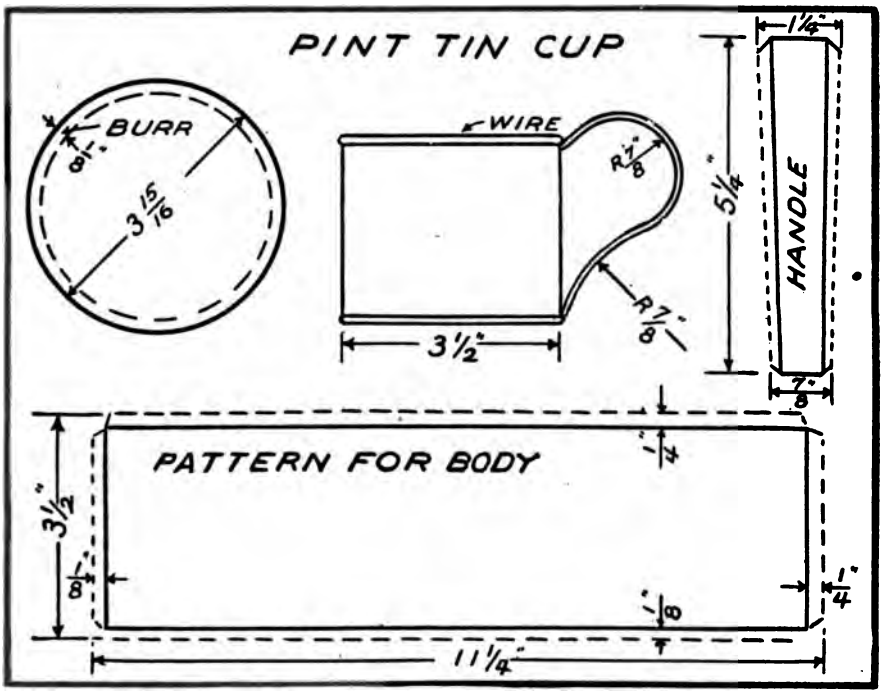

Fig. 45.

not fixed by rule. The capacity of any cylindrical cup may be found by multiplying the area of the bottom by the height, which gives the capacity in cubic inches. Since one gallon contains 231 cubic inches, the fraction of a gallon which the cup holds can be easily found.

Sometimes it becomes more convenient to use a bottom of a certain size, because the disk on the machine may cut only one size of bottom which is near the desired size. If so, the height may be varied to give the desired capacity.

If a very durable cup is desired, a high grade of charcoal tin may be used, but for most uses the grade called IC tin will be very well. It is of advantage to know that good material works more easily than cheap tin.

* By E. C. Graham, Director of Vocational Work, Evansville, Ind.

In laying out the body of the cup, it will be necessary to allow about one-eighth of an inch at the bottom for a burr or flange. Also, at the top we must allow for a certain amount of metal to go around the wire. This will be a little more than one-half the circumference of the wire and twice the diameter is usually allowed. At the ends where the lock seam is to be made, four thicknesses of metal are used in the seam and only one of them goes into the circumference of the cup. Thus it will be necessary to add three times the width of the fold to the length of the body for the lock seam. From $\frac{3}{32}$" to $\frac{5}{32}$" may be used, but a good average is one-eighth of an inch for the fold. Notches should be cut in all corners to allow the wire to meet properly and to prevent more than one thickness of metal at the edge.

In cutting the bottom, at least four times the width of the flange should be added to the diameter for the double seam.

The upper edge should be wired in the flat and the lock seam at the side carefully grooved before soldering it. The bottom may be fastened on by hand or, if a double seaming machine is available, it may be used to make the operation easier. The cup may be nearly water tight without soldering, but it will be safer to solder the bottom on the inside.

It may be decided to make the handle with what is called a false wired edge on the two edges, or a real wired edge may be desired. This last requires two pieces of galvanized wire about sixteen gauge. When shaping the handle, try to get a graceful curve which will fit the cup neatly. Secure a perfect fit before you solder it in place.

No finish is necessary except to clean the cup with a good polishing compound.

Since all articles made of sheet metal have the side seam made in the same way and since the operation of double seaming a bottom in place is the same as in this case, this problem represents a large number of projects. The same operations will enable the student to make pails, measures, cans, and similar articles without difficulty.

The pupil should notice cups purchased in stores and try to find out how they were made. If they are neater than your product, try to find out how the bottom was made and fastened in place. Does the machine-made cup show any signs of weakness that your cup does not show? Find out how stamped metal cups are made.

Is one metal just as good as another for stamping?

Are there any shops in your city where tin utensils are made?

What is tinplate and how is it made?

References—

Atkin's Sheet and Plate Metal Work.

Sheet Metal Worker's Manual, by L. Broemel, Frederick J. Drake & Co., Chicago.

Shop Problems in Sheet Metal, E. C. Graham, Evansville, Ind.

FUNNEL *

25. A large funnel has many uses around a home or shop. It is handy in filling the kerosene or gasoline tank, and the radiator. With the machines found in a school sheet metal shop, a funnel is not difficult to make, and making the pattern brings out some interesting and valuable principles in drawing.

The size of the funnel may vary within almost any limits depending upon any special use for which it is desired, but for general purposes the dimensions given in the illustration are satisfactory.

Tinplate or galvanized iron of about No. 27 gauge may be used. Tinplate is made of iron covered on both sides with a coating of tin. It is easily worked, is not easily affected by water or air and can be kept bright and clean. Galvanized iron is the cheapest material for making the funnel. The dimensions given in the drawing shown will give a funnel with a diameter across the top of about 10½" and across the small end about 1½". After the size has been decided upon, the funnel may be laid out and developed.

In laying out and developing a cone or a frustrum of a cone, it will be found that, if you use a semi-circular pattern, the result will be a cone which will have a diameter across the base equal to the slant height. This gives

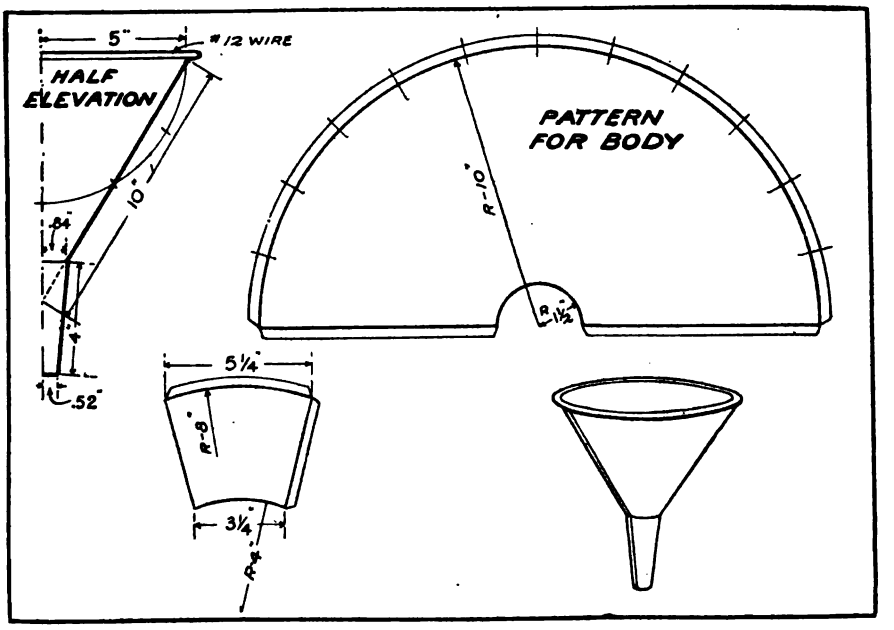

Fig. 46.

a satisfactory funnel, but, if one is desired which has different proportions, it may be obtained by increasing or decreasing the fraction of the circle used. In small funnels, less than a semi-circle is frequently used to make it easy to fold the edges in the machine.

* By E. C. Graham, Director of Vocational Work, Evansville, Ind.

All well-trained sheet metal workers can draft their own patterns. If desired, the funnel pattern may be drawn on stiff paper and transferred to the metal, or it may be laid out directly on the metal. In either case, allowance must be made for the seam outside of the radii used to lay off the funnel pattern and parallel to these radii, as shown in Fig. 46. Notches must be cut as shown to avoid a thick place in the seam at each end, also material must be left around the circumference of the pattern for wiring the edges.

In the ordinary lock seam, three times the width of the seam must be added to the edges before folding. The allowance for wiring is usually twice the diameter of the wire plus twice the thickness of the metal. The edge of the funnel is prepared to receive a wire by the aid of a turning machine. After the use of the turning machine, the wire is fitted to its place and partly closed in with a mallet. Then, the wiring machine is used to finish the work. Fold the edges of the body in opposite directions and form the funnel to shape. Groove the seam with a hand groover and solder inside.

The spout may be made of any reasonable length but should be large enough to fit over the small end of the body. If made with a lock seam and properly grooved with a hand groover, it will be stronger. Galvanized iron does not hold solder very well because the zinc will sometimes separate from the iron and take the solder with it.

A wire may be soldered up the outside of the spout and part way up the side of the funnel proper to let the air out of a vessel being filled. Also a ring should be soldered on the side of the funnel to be used in hanging it up.

The making of the funnel suggests a number of sheet metal projects which may be made. The principle of wiring may be utilized in making a pail, pan, or in fact, any open topped vessel. Seaming is required in most all sheet metal projects where assembling is done. Soldering is an essential part of the sheet metal worker's knowledge. Utilizing these three principles, and, with the aid of hand working machines, the beginner can make objects such as pans, scoops, dustpans, bread boxes, and toys, in an endless variety.

The project here is a typical one of the sheet metal trade, and it is made by processes used by the tradesman. It should give the workman an insight into duties of the sheet metal worker. The working of sheet metal is light, interesting and instructive. The variety of materials should lead into a study of the metallurgy of tin, iron, zinc, copper, brass, aluminum, and lead. Also fluxes and the principles of soldering are met in this work. The persons who become competent in these processes have mastered the preliminary steps in the sheet metal worker's trade.

References—

Sheet Metal Workers' Manual, by L. Broemel, Frederick J. Drake & Co., Chicago.

Shop Problems in Sheet Metal, by E. C. Graham, Evansville, Ind.

FOOT SCRAPER *

26. The metal foot scraper is one of many devices in use for cleaning the mud from shoes. It is an elementary problem involving the use of several bench

*By H. C. Milnes, Instructor of Machine Shop Work, Stout Institute, Menomonie, Wisconsin.

hand tools. The full size dimensions are given on the drawing, Fig. 47, and it is easy to calculate the size of the stock required.

The stock used for this is 16 gauge or 1/16" sheet steel.

To construct this exercise, lay out a rectangle 3"x5" on a sheet of steel of the required thickness. Place this on a cast-iron faceplate or any flat iron surface, and with a ⅝" cold chisel and 1½ pound ball pein hammer, cut out the required stock. File one edge and the two ends square and smooth. Lay out a ¼" radius at each corner. Clamp the stock in a vise and chip and file the corners round and smooth. Scribe a line 1" from the finished edge and lengthwise of the stock. From points on this line and 1½" from the ends, scribe lines at right angles to the finished edge. Lay out the holes and drill them. Countersink the end holes on one side and the center holes on the other before bending. With the cold chisel and hammer, cut along the short lines. Bend the base parts by clamping the stock.

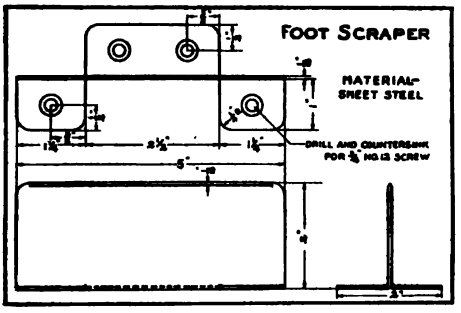

Fig. 47.

Besides being properly smoothed with the file, it may be desired to give the scraper a coat of black asphaltum paint.

There is no assembly work to be done on this exercise, but attaching it in a convenient place is sometimes a problem. Often it is desired to fasten the foot scraper at the foot of concrete steps. This necessitates fastening it to a concrete walk. To gain experience along this line, the workman should undertake this task. With a stone drill, make holes in the walk at places marked by using the foot scraper as a pattern. Using expansion bolts in the holes, secure the scraper to the walk. In case it is not desired or practical to fasten it to the walk, a wooden base for fastening may be sunk at the edge of the walk. On a board walk, it may be fastened with woodscrews or bolts. The method will depend upon the base to which it is fastened and serves as an excellent problem to test the ability of the workman to meet a trade problem.

The foot scraper exercise is given as a preliminary exercise to the outside caliper. It is an elementary exercise and introduces machine processes.

The machinist works in all kinds of iron and steel, using both hand tools and machines. Skill in projects as these given is a valuable asset to the machinist either in learning to do hand or machine work.

Many modifications of this foot scraper may be made, and it will suggest other similar machinist's problems. The scraper may be changed to serve as a plow, shovel, or hoe scraper or a moulder's strike, which is a kind of scraper. Original designs may be worked out and trade problems solved.

References—

Machine Shop Work, by Turner-Perrigo-Fairfield.
Machine Shop Practice, by W. J. Kaup, Jno. Wiley & Sons, New York.

6″ CALIPER *

27. The machinist's 6″ outside caliper is a very handy tool in several departments of the school, and is a very good addition to the young mechanic's tool kit. Inside calipers and dividers could be similarly constructed and are very convenient in a set of tools. This project requires careful lay-out work and, unless care is taken in cutting out the legs of the caliper, they will straighten out somewhat and the shape be injured. If a size different than the one given here (Fig. 48) is desired, work out a complete drawing of the size desired. Transfer the design to the metal from the drawing or pattern. In constructing this caliper, follow the dimensions closely and make the layout accurately.

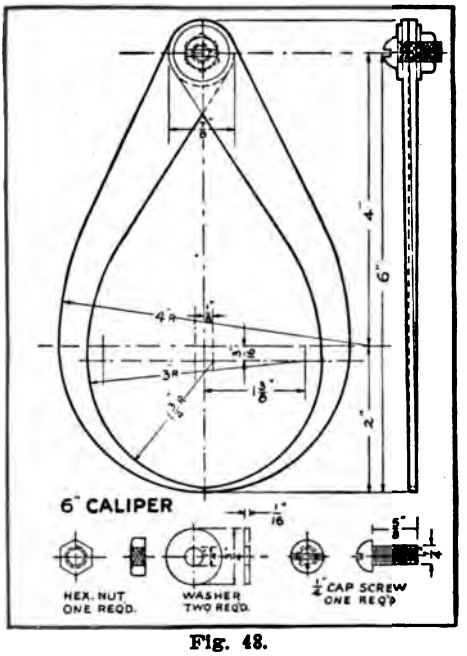

Fig. 48.

In cutting the leg from the sheet stock, use a sharp 5/8″ cold chisel on the straight lines and a 1/4″ cape chisel on the curves.

Cut out the curves on the inside of the leg first, then cut the leg from the sheet stock. This will prevent the leg from becoming distorted. File the edges with an 8″ half-round second-cut file. See that both pieces are exactly alike. Center punch and drill the hole for the screw. The caliper may be polished by grinding the surfaces on an emery wheel and polishing with emery cloth and oil. Assemble, using nut, washers, and cap screw.

There are a great many machinists in commercial shops who have learned what they know about the machinist's trade by operating various types of machine tools. Some of them have become very skillful in that branch and stand well in the trade as machinists. Such a machinist, however, never underestimates the value of being able to use hand tools skillfully. This is a part of the machinist's trade, as well as operating a machine, and every one can not do both. It is well for students to bear this in mind and never lose an opportunity to develop skill in hand work as this is by far the highest paid branch of the trade.

References—

Tool Makers' Kinks, by Colvin & Stanley, Hill Publishing Co., New York.
Modern Machine Shop Tools, by Wm. H. Van Dervoort, The Norman W. Henley Publishing Co., New York.

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*By H. C. Milnes, Instructor of Machine Shop Work, Stout Institute, Menomonie, Wisconsin.

MACHINIST'S CLAMP *

28. Steel clamps of various shapes and sizes are necessary tools in the machine shop. It is very often necessary to drill holes thru two or more pieces of metal for the purpose of riveting or bolting them together, and the machinists would find it very inconvenient to have to lay out and drill these holes separately. By the use of the clamp, this may be avoided. Small parts of machines that are being assembled are very often held in place by means of clamps to aid in more accurately aligning small shafts and bearings.

The dimensions of this clamp may be varied and large or small clamps constructed to suit the purpose for which they are to be used. Care should be exercised in changing the dimensions so as not to alter the relation of strength of the various parts.

The material to be used in the body of the clamp is machine steel. The best material for the screw is commercially known as 80-point annealed tool steel. Both kinds of material can be purchased in bars of suitable size.

All the dimensions on the drawing, Fig. 49, show finished sizes. Select a bar of machine steel having the same thickness and width as the body of the clamp. If the end of the bar is square, measure from it a distance equal to the length of the clamp. Scribe a line around the bar with a scratch awl and square. Clamp it in a vise and saw off the piece of stock by means of a hand hack saw. If the sawing is carefully done, much labor may be saved in filing and squaring the ends. Square and finish the surfaces of the stock by using a ten-inch bastard file followed by a smooth file. The surfaces may then be polished by placing a piece of No. 1½ emerey cloth on a flat surface, coating it with machine oil and rubbing the surfaces across it until they become highly polished.

By means of a square and scratch awl, lay out lines on one side and locate the center punch marks preparatory to drilling the holes for the round corners.

The stock in the throat of the clamp may be removed by sawing two grooves to the corners and drilling a series of holes along the back so that the stock may be broken out by means of a hammer and cold chisel. Chiseling and filing the three surfaces will finish them very satisfactorily. Locate a center punch mark for the screw hole and drill and tap the hole carefully at right angles to the lower jaw of the clamp. Use a $\frac{7}{16}$"-14 U. S. S. taper tap and hand tap wrench for this.

The clamp screw may be turned in a lathe, if the student has access to one in his shop. It makes a very good lathe problem in straight turning and thread chasing. If a lathe is not available, a $\frac{7}{16}$" x 3" square head steel set-screw can be bought and it will make a very satisfactory screw. To use the latter, it will be necessary to grind off the cup center on the end so that the surface of the work being clamped would not be injured by it.

To make the clamp screw by hand, cut three inches of thread on a $\frac{7}{16}$" bar of annealed tool steel with a stock and die, using lard oil freely on the die during the operation. Saw the screw off four inches long with a hand hack saw;

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* By H. C. Milnes, Instructor of Machine Shop Work, Stout Institute, Menomonie, Wisconsin.

drill a ⅛" hole thru the head; polish the screw and temper by heating to a cherry red and dipping in oil.

Another method would be to file a square end on the screw to be used in a monkey wrench instead of drilling the hole for a tightening rod.

The body of the clamp should be case hardened. This is done by placing the clamp in an iron box together with a special compound as cyanide of potassium, and heating the box to a cherry-red color. The clamp is then removed and plunged into oil. This will leave a very pleasing mottled finish.

The hand clamp is an exercise in tool making that may be made mostly by hand or by the use of machine tools. If made by hand, it will be desirable to construct the smaller sizes. The larger sizes may be made by milling the stock down to size on the milling machine and turning the screw in a lathe.

Each method leads into a different line of machine work that will prove extremely interesting.

There are two classes of men who work at the machinist's trade. One is the specialist and the other the all-around machinist. The specialist can

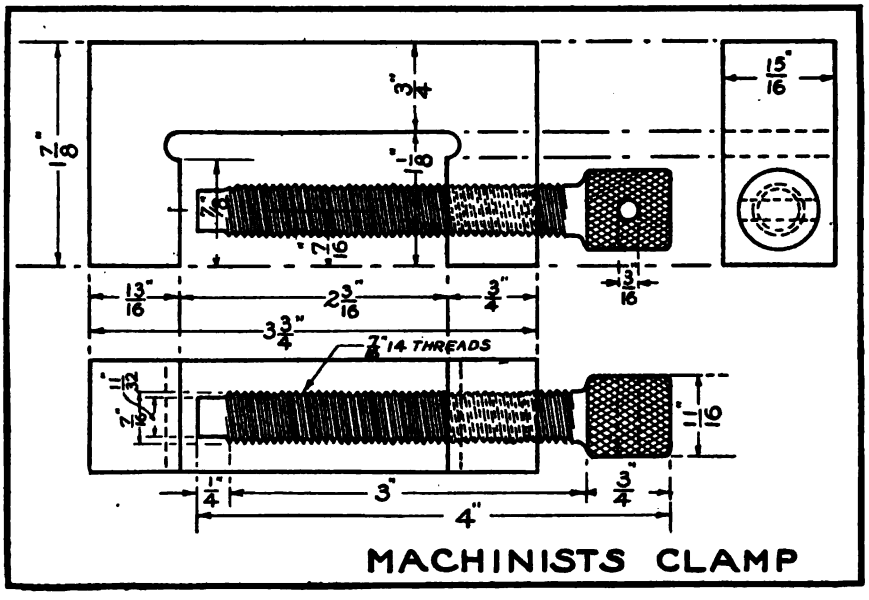

Fig. 49.

scarcely be called a machinist; he is more commonly termed a machine operator. The all-around machinist is a man of broader training and experience. He is capable of performing a higher class of machine work and is, in most cases, more intelligent and will eventually work up to be a foreman or superintendent. He is capable of doing both machine and hand work.

Constructing this exercise by machine leads to a broader knowledge of

machine operations, while the method by hand developes skill in hand work and leads into tool making which is a well-paid branch of the machinist's trade.

References—The following references deal with the machine operations and processes involved in this exercise:

Elements of Machine Work, by R. H. Smith, Industrial Education Book Co., New York.

Advanced Machine Work, by R. H. Smith, Industrial Education Book Co., New York.

Methods of Machine Shop Work, by F. A. Holsey, McGraw-Hill Book Co., New York.

CENTER PUNCH AND COLD CHISEL *

29. The cold chisel and center punch are in every mechanic's tool kit, and with the metal worker they are used as often as any tool he possesses. Both of these tools are often needed by the farmer for repair work around machinery. The chisel is used for cutting or chipping iron or steel, while the center punch is used for locating holes, marking or laying out lines, or driving rivets or bolts out of holes. The construction of these tools is simple and they may be made by the average boy. In addition to requiring very little experience upon the part of the worker, only the common tools found about the farm are needed in their construction. The forge, hammer, tongs, and grinding wheel are the tools needed.

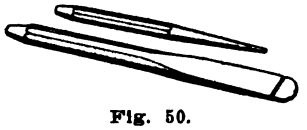

Fig. 50.

The size of these tools will vary according to the work that they are to do. The mechanic usually has different sizes of each so that he can use the one that fits the work best. For general purposes, the punch that is made from a piece of 7/16" octagon, tool steel will give satisfactory results. The chisel made from ⅝", octagon, steel and six inches long will do most of the work that will be required. As with the punch, the mechanic will have chisels both larger and smaller than this.

These tools are made from tool steel of about 80-point carbon, sometimes called chisel steel. This percentage of carbon gives a steel that is both hard and tough, it will hold a cutting edge and resist hammer blows to the maximum extent. This kind of steel is not expensive.

The work to be done with these tools will determine the size of stock and length of steel, but will not effect the shape. In every instance, the stock for either tool should be sufficiently large that there will be little vibration when struck with the hammer. Therefore, the weight of the hammer blow to be struck will determine the size of the stock. There is a definite relation of the body of these tools to the blade. Since the chisel is held between the thumb and the fingers when in use, the body of the tool should be long enough to accomodate the fingers. The center punch is held between the thumb and the first three fingers. The length of the body should be a trifle longer than the width of these fingers. The length of the blade of each tool will vary according to

* By R. F. Jarvis, Instructor of Forging, Stout Institute, Menomonie, Wis.

the work that the tool is required to do, the weight of the blow to be used, and the size of steel used for the tool. The taper at the head of the tool is added for appearance and has nothing to do with the work of the tool. It is not necessary that the tools be made from octagon steel. Hexagon, or round steel might be used, but the octagon material is more easily secured, and makes as satisfactory tools as either of the other shaped materials.

A mechanical drawing is not necessary in the making of these tools, but a well-made sketch will be of assistance in fixing in the mind the shape of the parts. The blacksmith uses very few mechanical drawings, but he does use sketches continually. He may make them upon the floor or upon a piece of note paper, but in either case, they serve the purpose.

The construction of the punch and chisel is similar in many respects. The extreme end of a piece of steel is heated to a cherry-red color and the head formed by drawing the end first to a square taper, then octagonal, and then round. The taper should not be more than three-quarters of an inch in length. The blade of the center punch is formed in this same manner except that a longer taper is used and the extreme end is drawn down to about an eighth of an inch in diameter. A cut is made across the end of the blade a short distance from the end and about half way through the stock. The punch should be perfectly true and straight.

The blade of the chisel is forged slightly different from the punch. It is heated to a cherry-red heat and drawn to a square taper, the end being left large enough to give sufficient width to the blade when drawn to a flat taper. The blade is drawn to a flat taper by working the stock over the horn and face of the anvil until the width and length of the blade is satisfactory. The cutting edge of the blade should be slightly wider than the original stock. The chisel is then made straight and true.

The heating of these tools is important. The forging heat of the kind of steel being used should be sufficient to produce a cherry-red color and the workman must be careful to see that the heat does not pass this temperature. Should the heat become higher, the grain of the steel is made coarse and the strength and cutting qualities of the tools are impared. When the heat in the tools has become lower than a dull red, they should be reheated. It is injurious to forge steel at a low temperature as well as to heat it too hot. The best forging heat is from 1450 degrees to 1600 degrees Fahr. The weight of the hammer blows should be in proportion to the size of the material being worked. The hammer blow should be heavy enough for the force to be exerted through the steel. Light blows affect the surface only and cause forging strains that may injure the tools.

In hardening and tempering these tools, the blade is heated to a cherry-red color and about one-third of the heated portion cooled in water or brine. The part of the blade in the cooling bath is moved up and down but is not removed entirely until that portion of the tool is the same temperature as the bath. It is withdrawn and the end of the blade polished with a piece of sandpaper, emery cloth or piece of brick in order that the temper colors may be more readily seen. As the heat that remains in the tool flows into the part of the tool that has been cooled temper colors begin to appear upon the blade. As the purple color reaches the cut across the blade that part of the tool is cooled the second time. If the red heat has entirely disappeared from the entire tool, it may be completely submerged. It is not necessary to harden or temper the head of the tool. The extreme end of each tool may be broken off at the cut across the blade

and ground to a cutting edge or point. Should the tool be cooled to such an extent that the purple color fails to appear upon the blade, the tool can be held near the fire for a few seconds until the color begins to show. In order to secure this color, it is necessary to raise the blade to about 530 degrees Fahr. and this heat may be obtained either from the fire or from the heated portion of the tool. No finish is necessary on these tools. After hardening and tempering they are ready to be used.

The processes involved in forging, hardening and tempering of the tools are typical of work involved in the making of a large number of tools that the mechanic uses. Practically all of the cutting or driving tools that must resist hammer blows are made in the same manner as the tools just described. The principles of heating and forging are common to all steel construction.

The center punch and cold chisel are not difficult problems to make, but they bring out fundamental processes involved in working tool steel. The construction is simple but the care necessary in heating and forging as well as hardening and tempering is typical of work done in tool steel. The tool smith and blacksmith are continually called upon to construct tools similar to these. In connection with this work, it is well for the worker to read books or trade papers on forging, hardening and tempering of tool steels. The methods that a workman uses may vary somewhat according to the shape of the tool, the material from which it is made, and the work for which the tool is designed. An understanding of these principles will help the worker to choose the proper method to follow in doing other work in tool steel.

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Forge Work, by Ilgen, American Book Co., New York.
Forging of Iron and Steel, by Richards, D. Van Nostrand Co., New York.
Non-Technical Chats Upon Iron and Steel, by Spring, Frederick A. Stokes Co., New York.
Heat Treatment of Steel, The Industrial Press, New York.

HAMMOCK HOOK *

80. The hammock hook is an article that is serviceable for many purposes besides the one indicated by its name. In the shop, around the home, and on the farm there are many uses for a well-made, strong hook. The hook may be used with an eye-bolt, chain, U-loop, rope or cable. It is an article that may be very readily made upon the farm or by any blacksmith, and is typical of some of the work that the blacksmith has to do.

Fig. 51.

The size and amount of stock necessary to make this project will vary according to the work for which the hook is designed. However, the hook is seldom called upon to support more than two or three hundred pounds and for this weight ½-inch round stock is sufficiently strong. A piece of stock three-eighths inch in diameter and eight inches in length is required for the hook shown in Fig. 51.

Soft steel is the best material from which to make this project. It is strong and easily worked at the forging heat. Also, it has the advantage of being reasonably cheap, or as cheap as any material from which the hook should be made.

The strains that are to be put upon the hook determine the size of material

* By R. F. Jarvis, Instructor of Forging, Stout Institute, Menomonie, Wis.

required, but do not effect its shape. The proper shaping of the hook involves a conception of the proper proportion of parts as the relation of the size and shape of the hook to the eye, etc. The effect of good workmanship upon the problem as a whole is indicated by the shape of the finished work.

A mechanical drawing is unnecessary in making the hammock hook, but a sketch of the problem before starting the work makes the proper shaping of the parts easier. The making of a sketch will fix in the workman's mind the exact shape and make it easier to accomplish results desired without loss of time and material.

To make this problem, one end of the stock is first squared and the eye formed without bruising the stock to any extent and keeping it as nearly round as possible. Unless the eye is round, the appearance of the hook is injured. The other end of the stock is heated to a yellow heat and two inches or more of the end is drawn to a round taper. The part of the stock from which the hook is to be bent is heated to a red heat and is bent into shape over the horn of the anvil. The extreme end is bent slightly outward with a pair of tongs or over the horn. The eye is heated to a red heat and bent downward over the side of the anvil until a line passing through the center of the hook will also pass through the center of the stock forming the eye. The hook is turned at right angles and is trued up in the same way as before. In straightening the hook, it may be held in the vise or in a pair of tongs, the vise being the better of the two.

There is no need of any particular finish to this kind of work. In order to prevent rusting for some time, oil or grease may be burned into the surface of the project by heating the metal to a black heat or hot enough to burn oil and rubbing with oily waste. This will give a black finish which will protect it and improve the appearance.

The processes involved in the making of the hammock hook are typical forge processes and may be applied in many other ways. Rings, eye-bolts, hay hooks, single-tree hooks, and strap-hooks embody the same constructive principles.

The hammock hook is a simple problem and to the experienced blacksmith would offer but few difficulties, but, to the student or to an inexperienced worker, it will seem rather difficult to shape satisfactorily. If one has any aptitude for forging, or cares to make any further problems involving the same processes he will find less difficulty as he proceeds. The processes of bending and drawing of iron are fundamental in blacksmithing and must be mastered before the worker can expect to become proficient in the use of the tools of the smith. As the worker masters the more fundamental of the operations of the blacksmith, he will begin to realize the skill of hand that a smith must possess and will take an increased pride in doing good work himself.

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Forge Practice, by Bacon, Jno. Wiley & Sons, New York.
Forging of Iron and Steel, by Richards, D. Van Nostrand Co., New York.
Forge Work, by Ilgen, American Book Co., New York.

BICYCLE BUNDLE CARRIER *

81. The uses for a bicycle bundle carrier are varied, and any boy having a bicycle can well afford to make this project. The size of the carrier may be made to suit individual tastes, but the dimensions given on the drawing have been found satisfactory, both from the standpoint of appearance and usefulness.

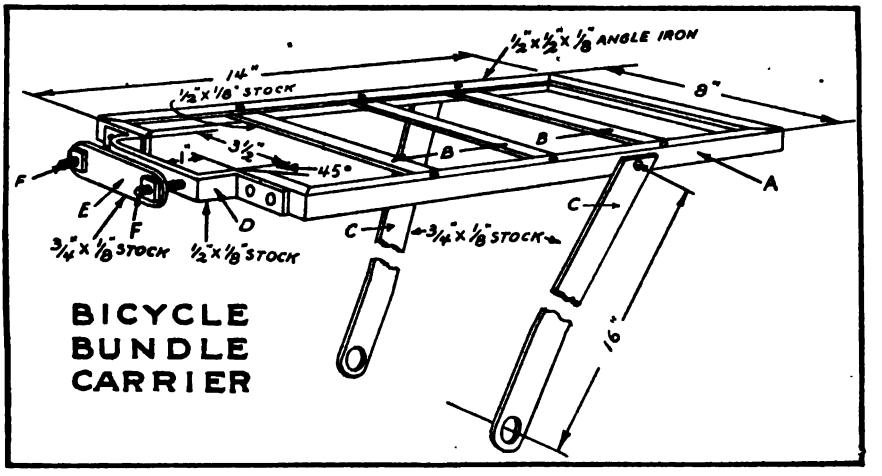

Fig. 52.

Some parts are to be bent at a sharp rigle-angle and the iron used must be of a kind that will not break under this treatment. See Art. 183, Sec. 2. The sizes of stock indicated are amply strong for ordinary use, but may be changed, if desired. See Fig. 52. A stock size should be selected. It may be desired to change the width and length of the frame to meet particular needs. The exact length of each of the parts is not shown in the illustration. A scaled working drawing, showing plan and end view, also all details modified to suit the needs for the carrier should be constructed. The end view of the leg **C** should be carefully drawn to show the proper amount of bend at the lower ends to insure their fitting squarely upon the axle of the rear wheel.

The length of the legs, 16", is correct for a standard 28" wheel. Be sure that the width of the yoke **D** (shown here 3½") will allow the stove bolts **F** to be spaced far enough apart to pass outside of the rear fork on the bicycle just below the saddle.

The holes in **E** and **D** must match and therefore must be accurately spaced. They must be of the proper size to take 3/16" stove bolts.

The legs **C** are right and left-hand and are not bent in the same direction. All parts riveted to the frame require 9/64" holes for the ⅛" rivets. The large hole at the lower end of the legs should be drilled to fit the rear axle.

Iron stretches at the corners when bent and in the drawing shown, allowing 7⅞" for width and 13⅞" for length before bending will give a frame 8"x14"

* By R. W. Hastings, Instructor Practical Arts Dept., Chestnut Street Junior High School, Springfield, Mass.

when completed. At each of the four corners a triangular section of the horizontal flange of the angle iron must be cut away to allow the vertical flange to bend to a right angle corner. The rivet holes for the cross bars B are drilled ⅛" from the inside edge of the frame and countersunk on top, to bring the rivet heads flush with the frame. The yoke D is fastened to the frame by two rivets on each side, but only one hole on each end should be drilled in the frame at this time.

Holding the sides of the finished frame parallel, measure the space for the bars B and also the exact distance for the rivet holes in the bars. Make all cross-bars exactly alike to insure their holding the frame parallel. The yoke D is bent to shape in the metal working vise and then the rivet holes are drilled.

The work of assembling the carrier parts consists of riveting the parts together. There are two types of riveting required upon this piece of work. The fastening of the cross-bars calls for the forming of a countersunk flat head, while the legs and yoke each are to be riveted by forming round heads upon the rivets. In riveting the cross bars B, the heads of the rivets should be under the cross-bars and the riveting done on top of the frame. The riveting should be done by striking many light blows each carefully gaged and placed rather than by striking heavy blows.

The yoke and legs are riveted so as to leave a round head upon the rivets. Have the heads of all these rivets on the inside. The two holes to be made in the frame for the yoke and which were left undrilled may be made after the first two rivets are in place. Finish with two coats of a suitable colored enamel.

The making of the bundle carrier should suggest other needed projects. For example, another bicycle accessory which may be constructed in a somewhat similar manner is a drop stand, such as motorcycles and some bicycles carry.

The process of riveting with which these projects make us familiar has been a very important factor in the development of metal working trades. Without rivets we could not have built great skyscrapers, bridges, boilers and battleships. The necessity of selecting the proper kind of iron for each project leads into a study of the kinds, composition and methods of preparing iron for such varied objects as "I" beams, steel rails, iron castings, knives, springs, etc. A study of these iron products leads us through the factories, to the forge rooms, foundries, steel mills, smelting works, and to the iron mines.

References—

Practical Sheet and Plate Metal Worker, by Rose.
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Industrial Readers, by Eva March Tappan.
A, B, C of Iron and Steel, Penn Publishing Co., Cleveland.

OXY-ACETYLENE WELDING AND CUTTING*

82. Welding is the process of joining two pieces of metal by fusing the joint into a solid piece of the same character throughout. It was formerly done entirely by means of the hand forge and hammer. Oxy-acetylene welding is a

* By R. W. Austin, Welding Expert, Chicago.

recent improvement over this method. The inflammable gases used are controlled as they pass through a blow pipe under pressure. Also the point of application of the heat can be controlled, it can be applied directly without covering the joint with solid fuel; the temperature can be raised to the fusion point quickly; and the welding apparatus can be taken to the work, if necessary. Many pieces can be welded that could not well be placed in a furnace and heated. Also, pieces can be welded that could not well be repaired by the older method because they could not be hammered.

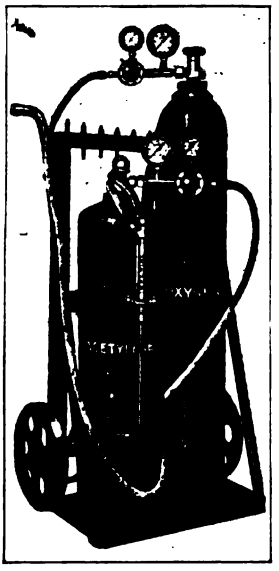

Fig. 53.

The complete oxy-acetylene welding machine is shown in Fig. 53. Gases pass from each tank through separate tubes and issue from the nozzle at almost the same point. Oxygen passes from one tip of the nozzle and acetylene from another. At the point where the gasses meet, combustion takes place and the heat is generated. A bar of metal similar in composition to that of the part to be repaired is needed. It is called a "filler" rod and is melted and fused with the molten edges of the weld. The operator must have a pair of colored goggles to protect the eyes from the intense light.

Repairing an automobile fender bracket furnishes an example of the process of oxy-acetylene welding. However, it is best that the beginner first gain experience in welding on scrap pieces of metal.

The fender bracket to be repaired must first be cleaned, lined up and the edge shaped for welding. The bracket should be beveled out from the sides and then lined up. The edges of the two parts are heated at the same time and brought to the fusion temperature. The filler rod tip is brought to the same temperature and applied to the joint, with the hottest part of the flame playing on the end of the rod. This causes the joint edges and the filler material to flow together.

Make sure that all metal engaged is melting. Add sufficient material from the filler rod to build up the weld as high as the original piece.

Oxy-acetylene welding is finding almost universal use. It is used in the sheet metal worker's trade, the machine shop, and by the blacksmith. It has taken the place of soldering in many cases, has largely supplanted riveting in much construction work and can be used on many articles that were formerly welded by the forge and hammer method. Auto parts, broken machinery, defective castings, damaged pipes, steel rails, etc., can all be repaired. Sheet steel bodied tanks, automobile, airplane, and railroad car bodies as well as armor plates for ships can all be built up seamless by the aid of this method. In the general repair shop or garage, broken machine parts, and broken tools, can be quickly and neatly repaired, thus saving the necessity of having to purchase new parts. Fig. 54 shows something of the variety of uses to which the general repair man can put this process. It is coming to be a standard part of the equipment in the blacksmith shop, garage and machine shop, where metal parts made of cast iron, steel, brass, bronze, aluminum, lead, etc., of almost any size or thickness can be welded.

Oxy-acetylene welding can be taught in any school that has the proper

equipment. It does not take long for an intelligent student to be able to weld simple work. It takes more time and practice to be able to make neat welds and learn how best to overcome the buckling difficulties that occur.

Fig. 54.

The cutting of iron and steel may be done with oxy-acetylene but a different torch is used than the one used in welding. A sharp clean cut can be made with ease and the process is used in cutting all kinds of metal plate. Holes can be made readily in boiler plates, and pieces cut out. The process is much used in car and shipbuilding. On thin sheets of steel, say ¼" thick, cutting may be done as rapidly as 75 lineal feet per hour. In the general shop, or garage, the cutting operation is not so important as the welding process.

References—

Sheet Metal Worker's Manual, by L. Broemel, Frederick J. Drake & Co., Chicago, Ill.

ROOF TRUSS *

33. Trusses are used in roofs and bridges to span wide spaces without the use of intervening supports. The first trusses were made of wood and when used for long spans were very heavy and cumbersome. Now, trusses are made of either wood or steel or a combination of the two materials and in a great variety of forms and sizes. Steel trusses appear much lighter and present a

* By Earl D. Hay, Instructor in Industrial Arts Dept., State Normal School, Oshkosh, Wis.

neater appearance than the wooden ones. Small trusses are made up complete in a steel fabricating shop and transported to the place of erection as a unit. Large trusses are made up in several sections and are bolted and riveted together at the place of erection.

In making a steel truss, skilled workmen are required. Structural draftsmen make the designs and drawings, while templet makers layout the templets from the drawing. Other workers cut the structural steel shapes to the proper length and punch or drill the holes, after which the pieces are assembled and the rivets driven by the riveters.

It is impracticable to secure the steel and make a complete truss in the school shop because of the expense, but the structural drawing of a truss can be made and the templets worked out from the same.

The drawing shown in Fig. 55 is finished as it would be when it comes from the designer to the draftsman. The dimensions and sizes given are sufficient to enable the draftsman to work it up into a finished form.

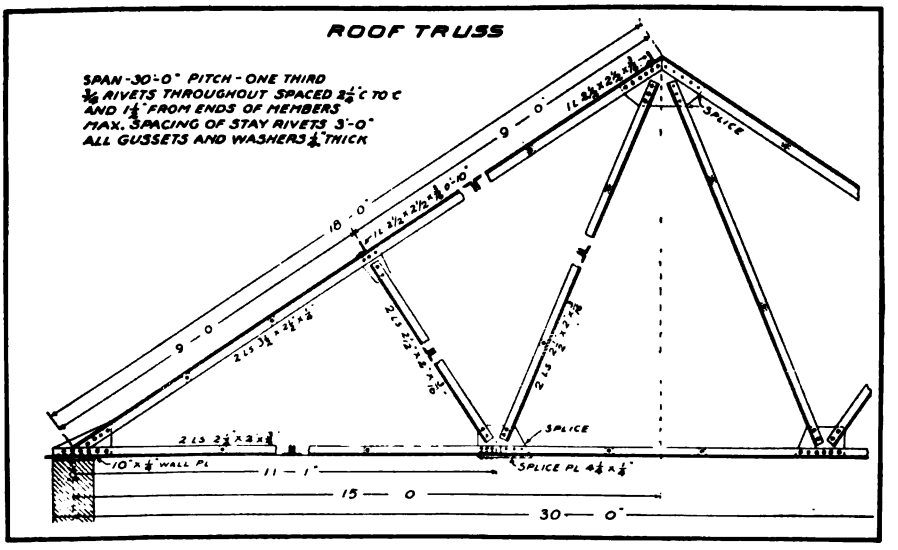

Fig. 55.

Any wood that is suitable for pattern making will be suitable for the templets. Pine is probably best. It is essential that the wood does not warp.

For variety in design, a truss might be worked out similar to the one shown except designed to support the roof at four points on each side instead of three. Or a truss might be designed with the tie rail raised in the center in order to increase the head room in the building. However, if these changes are made, it should be determined whether these changes would change the size of the members or the number of rivets in the joints.

Complete assembly and detailed drawings of the truss and a bill of material must be made. The stress diagram which is usually placed on the assembly drawing may be omitted.

Before starting the drawing, the student should discover for himself from textbooks and other sources how structural drawings differ from machine drawings in the selection and placing of views, dimensioning of lines and angles, special conventions for riveting, use of notes, and width of lines.

In laying out the templets, first cut the stock and reduce it to size. For example, in laying out the templet for a $2\frac{1}{2}$"x$2\frac{1}{2}$"x$\frac{5}{16}$" angle 16'-0" long, a piece of stock $2\frac{1}{2}$" wide and 16' long and $\frac{5}{16}$" or $\frac{3}{8}$" thick would be used. After sizing, the rivet holes must be carefully laid out and drilled. The templet can now be used by laying it on the leg of the proper sized angle and marking off the length and the position of the rivet holes. If the other leg of the angle has a different spacing of holes a templet would be required for it also.

The templet, to be preserved, should be given two coats of shellac to prevent moisture from swelling or warping it.

After all of the templets have been made it is a good plan to lay out the structure on the floor and bolt the templets together to secure a check on the work and make sure everything is as it should be.

The method outlined above for building a steel truss may be used for almost all kinds of structural steel work, such as beams and columns, steel ship frames, railroad trusses, and girder bridges. After laying out the above truss, the student should be able to handle structural steel layouts of a similar nature without much difficulty.

Structural steel drafting and templet making are but two of the trades to be found in the great fields of structural steel work. While only a few decades ago buildings and bridges were built of brick, stone and wood, now we find the frames of new buildings are made principally of structural steel and reinforced concrete. Structural steel made the skyscraper a possibility.

The work of the riveters, fabricators, and templet makers requires considerable skill and practice for proficiency. Their tasks are classed as manual occupations. The structural designer's work is highly technical and requires an engineering education. It is interesting work, as the designer must determine the size and shape of the structure as a whole and then the size and shape of the parts and the size and number of rivets to hold them securely together.

Make a list of the trades connected with the structural steel industry. Also make a list of the industries upon which the structural steel industry is dependent.

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SINGLE ACTING STEAM ENGINE *

34. Of the mechanical inventions which have been put to the service of mankind, there is hardly one which has contributed as much to his advancement as that of the steam engine. Power for a large part of our manufacturing, the development of electricity, transportation, both by land and sea are some of its more important services. Steam engines were known, at first, as fire or heat engines because steam is only the medium through which heat is made to work.

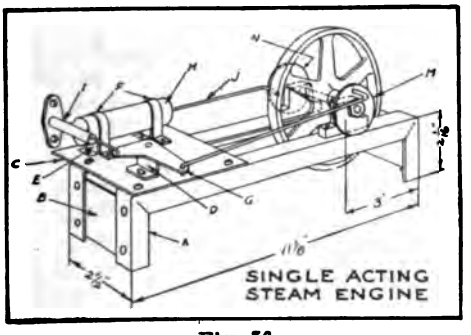

Fig. 56.

The steam engine was first applied to transportation in the propelling of a steamboat. The first steamboat to be of any practical value was built by Robert Fulton in 1807. The first one to cross the Atlantic was built in 1819. The first application of steam to a railroad in the United States took place in 1829. Now, thousands of miles of railroad reach into almost every portion of the United States.

To learn how so important a piece of machinery is constructed and how it operates, a small simple engine, working on the principle of the modern engine, may be constructed. See Fig. 56. The general over-all dimensions are shown in the sketch and should be carefully followed. The success or failure of the engine to run when completed will depend largely on careful and accurate work. Each part must fit properly to make a smooth running engine. No detail of the end plates has been given as their size can be determined from the general dimensions.

The construction of the engine requires different kinds of metal, each selected because of its adaptability to the purpose for which it is used. The angle-iron for the base is heavy, giving a strong and solid support upon which to build, and also soft enough to be easily bent into shape. The sheet metal parts must be made from a gauge stock which can be cut with hand snips. No. 22 gauge will be strong enough, except in the case of the rocker arm bracket and the bed plate, which should be made from No. 20 gauge sheet iron. Cold rolled steel (C. R. S.) rod should be used for the shaft rather than iron, as it comes much more accurate to size and its more uniform grain makes the threading for the nuts much easier. Lead is easiest used for casting the wheel, as it can be melted over a gas burner. Those parts coming in contact with the steam must not rust, so brass tubing is used for the cylinder and valve chamber.

In undertaking the making of the drawings for the steam engine, a set of details of the parts will be of much more value than an assembly of the complete engine. Place full notes upon the detailed drawings of special construction, drill sizes, and metal used.

The two side bars A are made from $\frac{5}{8}$"x$\frac{5}{8}$"x$\frac{1}{8}$" angle iron 15" long. Measure 2" from either end for the bend and cut out a triangular piece in the vertical

* By R. W. Hastings, Instructor Practical Arts Dept., Chestnut Street Junior High School, Springfield, Mass.

flange to allow the other flange to bend. The ends of the frame should be drilled for the end plate rivets. All holes in the frame are $\frac{9}{64}$".

Make the end plates B next and drill them to fit the side bars. Consider

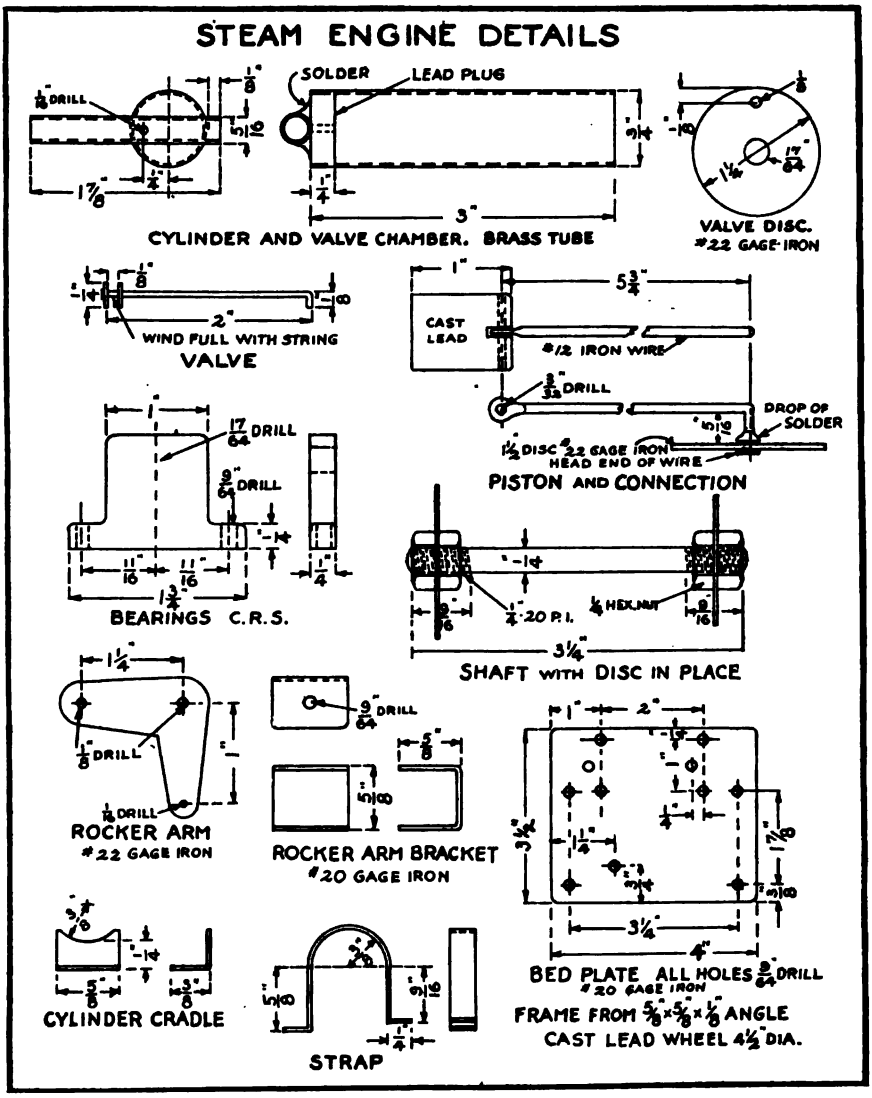

Fig. 57.

carefully their length in order to give the correct width to the frame when assembled. Rivet the plates in place and true up the ends of the legs to make the frame stand without rocking.

When making the bed plate C, locate all holes accurately as they determine

the position of the different parts. Cut the rocker arm bracket D, the two cylinder cradles E and the two straps F to shape and rivet them in place. The straps are riveted only on the long leg which should be on the side towards the center. The other side is to be drawn down by a bolt and nut after the cylinder is in place. The rocker arm G must be loosely riveted to its bracket.

The bed plate may be held in place on the frame and used as a templet in marking the holes for its fastening bolts.

After the bed plate is in place, work may be started upon the cylinder H and the valve chamber I. Do not put tubing into a vise except when held between two blocks of soft wood notched to fit tightly around the tube. A bent tube is of no use as an engine cylinder. The tube may be plugged with a cork and the lead poured in at one end. Be sure to tin the surface to which you wish lead or solder to stick.

After plugging the cylinder, file a small groove across the center of that end, using a round file, and solder the valve chamber in place in this groove. A $\frac{1}{16}$" hole is drilled through the valve chamber and the lead plug into the cylinder as a steam inlet and soldered up on the outside. Put a piece of $\frac{1}{4}$" C. R. S. inside the valve chamber under the hole to be plugged to keep solder from getting in. The cylinder may now be fastened in place.

The bearings are sawed from a bar of cold rolled steel and filed to shape and size. The shaft holes should be accurately spaced from the base of the bearings to insure the shaft's lying level between them. Mark off the holes in the frame from the bearings themselves, keeping the shaft in place as an aid to correct alignment. Do not attach the bearings until after the wheel has been placed upon the shaft.

In casting the lead wheel, it is not necessary to have a wooden pattern as any wheel of about the right size may be used and reproduced in lead. Almost any dirt containing no clay will do for molding sand, if the nearest foundry can not provide you with a little molding sand. Have the lead very hot, blue in color on the surface. The sand should be as dry as possible, yet holding together, After casting, the wheel should be cleaned and filed smooth and a hole drilled through the hub.

The lead piston is cast in a piece of the same tubing from which the cylinder is made. Carefully coat the inside of the tube with soot to prevent the lead from sticking. After attaching the piston rod to the piston, the rod may be held in a vise leaving the piston in a position to be sanded (with a strip of very fine sandpaper) to a nice sliding fit inside the cylinder.

The little valve discs are soldered to the valve rod K not more than $\frac{1}{8}$" apart and soft cotton string wound evenly between them. Oil the string and force the valve into the tube and rub back and forth until it slides easily. The length of the valve rod should be such that when the rocker arm stands square the valve will just reach the steam inlet into the cylinder. With the valve in this position, the connection L should reach the disc at the top as illustrated.

Study carefully the relative position of the valve disc M to the crank disc N in order that the valve may open and close at the proper time.

All of the engine parts except the brass parts and the connections should be enameled to protect them against rust and as a means of decoration. Polish the brass and cover with a thin coat of white shellac to keep it bright.

Having completed the engine, the next step is the making of a boiler. A tight covered can makes a foundation upon which to build. If a more elaborate design is desired, one may be built up of tubular construction as used on donkey

engines. The building of the boiler is a separate problem and is not taken up here.

Besides the boiler, a great many other projects may be found that could be made from sheet metal. The processes used here may be utilized in the making of a water turbine, windmill, and other machines.

The construction of this simple engine should be compared to the making of the modern engines of today. The different kinds of engines, their uses, with the advantages of each kind should be considered in this connection.

Also this construction work should lead into a discussion of the work of the engineer, what he must know, his duties, and how to run an engine. A locomotive engine may be studied in connection with this stationary engine.

References—

History of the Steam Engine, by Thurston.
One Hundred Years of the Locomotive, pamphlet by Erie R. R.
Locomotives, Simple, Compound, Electric, by H. C. Regan.
Power Plants, by M. H. Schneider.
How It Works, by Archibald Williams.
Great American Industries, by W. F. Rochelian.

WATER MOTOR *

85. The water motor is an excellent device for furnishing light power in the home. It can be attached to a faucet in the same manner as a hose, and used to run sewing-machines, small dynamos, erector contrivances, and fans. It may be furnished with a corundum wheel for grinding knives, scissors and skates, or with brushes and buffing wheels for polishing shoes, cleaning silver, and washing bottles.

Water power was used more than two thousand years ago, there being evidences that the early Egyptians used the current of the Nile for grinding corn. How long the water wheel had been in use before history refers to it, we can only conjecture.

From the crudest kind of paddle wheel mounted on a float and slowly turned by the current of a stream, the water-motor has been developed through the ages and is now being used more extensively than ever before. The hydraulic turbine is considered to be the most efficient of prime movers.

The drawing is intended to be suggestive, but all essential dimensions for this particular motor are given.

While any kind of close-grained wood may be used for the case of the motor, a soft grade of cypress is suggested. Cypress is also suitable for the wheel. Babbit metal is best for the bearings, but lead may be used. Lead is used for the nozzle. A five-cent faucet strainer makes a good coupling.

Sheet tin or zinc is used for the disc on which the buckets are cut.

The water motor may be made any size to suit the individual fancy, but the larger the wheel, the more efficient the machine. The buckets can be placed more advantageously in a large wheel, since they will move with less angularity to the direction of the flow. While a large wheel will make fewer revolutions per minute than a small one, this is compensated for in the increased load that can be carried.

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* By C. S. Goldsmith, Supervisor of Industrial Arts, Carlstadt and Oradell, N. J.

A working drawing of the assembled motor as planned by the student, together with details of the nozzle and wheel, should be made. Also, drawings of the jigs and special appliances used in construction should be made.

In construction, the water motor is simple. No difficulty will be experienced with the case. Undercut (or counterbore) the bearing holes in both side pieces, and then pour the bearings as shown in (a), Fig. 58. The same sized rod as that used for the shaft may be used in doing this, in which case the bearing will have to be eased with a rat-tail file.

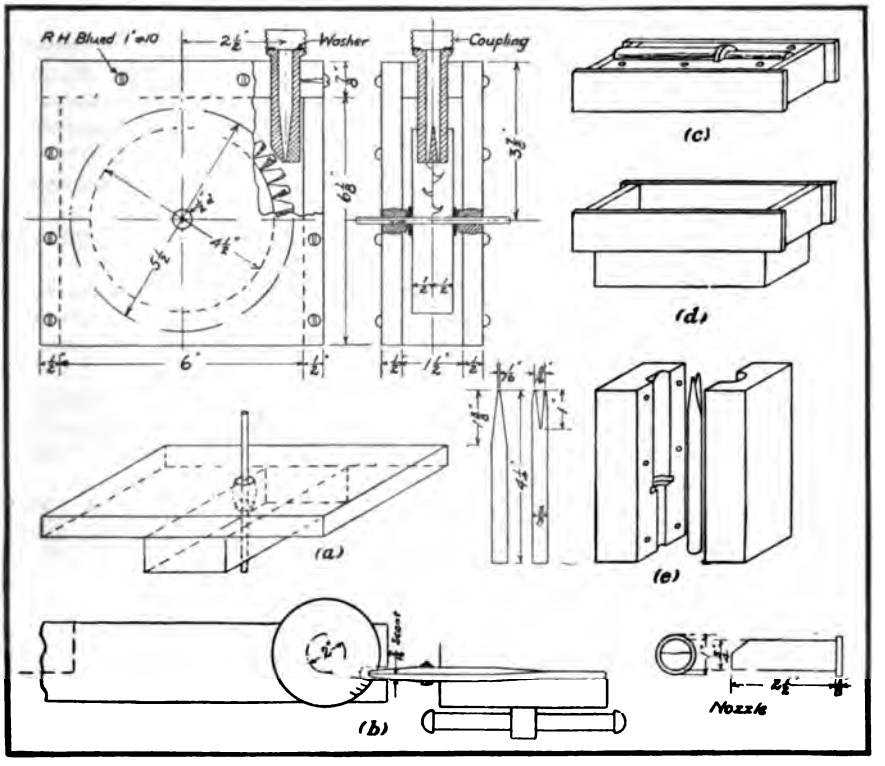

Fig. 58.

The wheel is made by sawing out two discs from ¼" stock and nailing them together with the bucket disc between.

The cuts for the buckets should be made as shown in (b), Fig. 58. Place a pair of tin snips in a bench vise and clamp a board on the end of an adjoining bench. Drive a nail through the center of the disk and fix to the board so that each cut, if prolonged, would be tangent to a two-inch circle. See (b) in Fig. 58. Make the first cut and then revolve disc 7/16" for each succeeding cut. After the wheel is put together, bend the buckets to the proper shape, using round-nose pliers.

The pattern for the nozzle may be made in halves and molded in sand, or it may be made solid, as shown, and molded in plaster of Paris. If made the latter way, the pattern should be well shellaced and oiled to insure a clean

draw from the plaster mold. Mark clearly the longitudinal center line on the pattern so that it may be pushed down into the soft plaster to half its diameter. See (c) in Fig. 58. Take any round-end instrument and push it slightly into the surface of the plaster to form the joggle holes. When the plaster has become hard, shellac and oil the surface. It is well to loosen the pattern before proceeding with the second half, so that the two halves may be easily parted when finished. To make the top half, merely lift the frame almost to the top of the bottom half, as shown by (c) and (d) in Fig. 58, and pour the plaster in.

To make the nozzle, clamp the two halves together with core inside. See (e) in Fig. 58. Then pour the lead just hot enough to run. The ⅜" dowel used as the core should be made as shown in (e), Fig. 58, and should be sandpapered smooth and with a slight taper to facilitate drawing out. Make sure the mold is well dried out before pouring lead into it. When the lead has cooled, the extreme ends of the two holes should be reamed out a little with a countersink so that the jets of water will not break up into spray on leaving the nozzle.

The wheel and the interior of the case should be given two coats of asphaltum varnish. The outside may be painted as desired.

The nozzle should be adjusted properly before the cover side of the case is screwed on.

The experience gained on the water motor will enable one to construct a steam turbine, since both machines embody the same essential principle of a series of vanes being set in motion by the force of a jet of water or steam.

Windmills are also operated on the same principle.

The skill developed should enable one to construct various machines for utilizing the power furnished by the water motor. An interesting problem is to work out a jig-saw by making use of an ordinary coping-saw frame. A drill-press may be constructed and successfully run by the water motor.

Motive power of some sort is essential to practically all industries. Many trades are represented in the manufacture of the various engines and motors used, while thousands of men are required to operate them.

References—

History of Corn Milling, 4 vol., by Richard Bennett and John Elton, Simpkin, Marshall & Co., London.

Natural Sources of Power, by Robert S. Ball, D. Van Nostrand Co., New York.

Water Power Engineering, by Daniel W. Mead, McGraw Publishing Co., New York.

Hydraulic Motors, Turbines, and Pressure Engines, by G. H. Bodmer, D. Van Nostrand Co., New York.

The Encyclopedia Britannica, Vol. 28.

HAND KNITTING LOOM *

36. Girls become familiar with real knitting needles, and learn to knit in the usual way. Boys, on the other hand, become familiar with tools and learn almost nothing of knitting or textile operations. The following loom was evolved for use of boys and girls and can be employed in the knitting of socks or other articles. The general dimensions of the loom are indicated on the drawing, Fig. 59. The size may vary depending upon the size of the article to be made. It may be small enough for a wristlet or large enough for a sweater. Other shapes may also be made. After the size desired has been decided, a detailed drawing should be made from which to construct the loom. After the drawing has been completed, the stock should be selected.

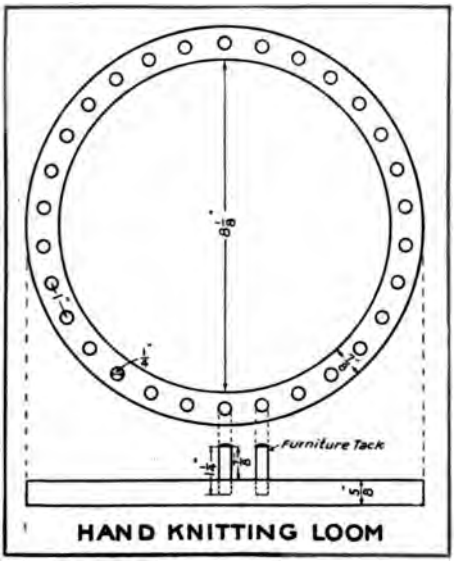

Fig. 59.

The circular part of the loom may be made from 3-ply veneer, ¼″ thick or more, or from ⅛″ to ⅝″ white wood or basswood so glued together that the grains of the two pieces cross each other. The pegs are made of ¼″ dowel rod and are 1¼″ long.

After the stock is selected, the circle should be sawed out by means of the coping saw, or turning saw (Arts. 28 and 29, Sec. 4). The holes should be bored half way through the piece with a $\frac{3}{16}$″ or ¼″ bit. For the pegs, dowels $\frac{3}{16}$″ or ¼″ by 1¼″ should be used. If the circle is 19½ inches in diameter, it will require 30 pieces of dowel for the pegs. These should be thoroughly sandpapered and waxed so that no rough places will come in contact with the yarn. A furniture tack is driven in the head of each dowel to prevent the yarn from slipping off too easily.

The bed of the loom may be shellaced and waxed before placing the dowels. The dowels may be shellaced and waxed, or finished in oil, then secured in the holes with glue.

Fig. 60.

The principle of this loom may be applied to other forms of looms. Instead of the circle, two strips of wood may be placed parallel to each other about ¼″ apart, and secured to a base in such a manner as to leave an opening for the knitted article. By means of this type of loom, a scarf may be knitted or even a sweater.

The hand knitting loom is closely connected with the entire industry of knitting and weaving. This art is one of the oldest and dates back to before Bible times.

* By Raymond C. Keople, Supervisor of Manual Training, Rochester, N. Y.

Look up all references you can find on weaving and knitting. Trace the development of the art through the Chinese, Hindues, Egyptians and down through the Indian tribes. What kind of fibers are used in making yarn? How are the fibers prepared? Make a study of the different kinds of yarns. In what way do they differ? Visit the weaving or knitting factories in your vicinity.

References—

Handicraft for Girls, by McGlauflin, The Manual Arts Press, Peoria, Ill.
Wool Manufacture, by Beaumont, Geo. Bell & Sons, London.
Hand Loom Weaving, by Todd and Coaley, Rand McNally & Co., Chicago, Ill.

THE FOOT POWER LOOM *

87. Notwithstanding the introduction of the power loom and all its wonderful possibilities, the hand loom still survives and seems likely to continue in use

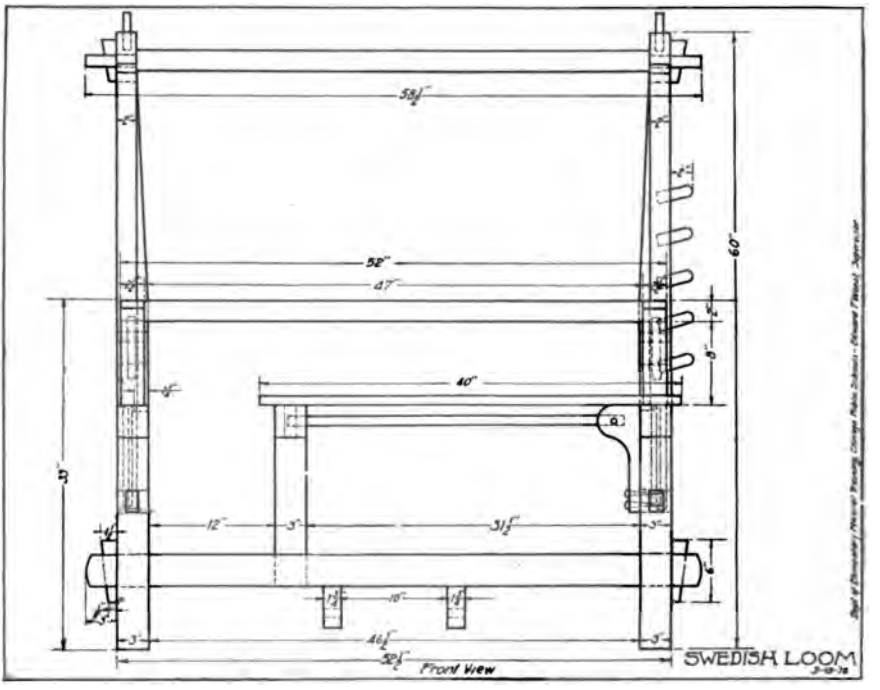

Fig. 61.

since numerous schools and handicraft societies, as well as many independent art workers, are becoming interested. The appreciation of handwork has, during the past decade, increased in the estimation of the public.

* By Edward F. Worst, Supervisor of Elementary Manual Training and Construction Work, Chicago.

In various European countries, as well as in India, China, and Japan, hand loom weaving still continues. In Norway and Sweden, a very successful line of home industry is carried on by many women who find it necessary to aid in the support of the family. This may also be said of the women in the Orkney and Shetland Islands.

Of late, much has been written of the beautiful hand-weaving done by the women in the mountains of Kentucky and Tennessee. So attractive is this work that little difficulty is experienced in the disposal of the articles woven.

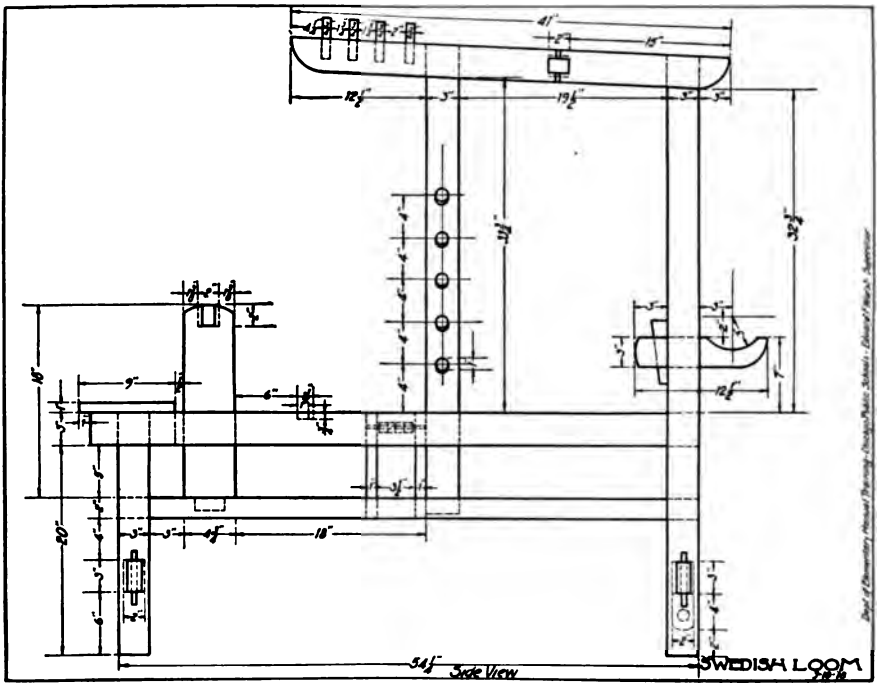

Fig. 62.

There is no doubt as to the superiority of a well-made, hand woven article. This is plainly shown, if the hand made and the machine made articles are compared. Hand loom weaving, too, is superior to machine weaving, if judged by the effect it is likely to have on the worker. The hand weaver is employed in a pleasant, ingenious occupation, which exercises all his faculties, while the attendant on a power loom is engaged in a monotonous toil, in which no quality but intense watchfulness is required.

It is said that one-fifth of the working world is now occupied with weaving, its allied arts, and the distribution of the products of the industry.

Many kinds of looms have been invented: The upright or vertical, such as the Navajo Indian loom or some forms of the tapestry loom; the horizontal loom, like those of the Moors of the Philippine Islands, and of the Zuni and Pueblos of America, a form also seen in the hand loom of Colonial days and in the power looms. Fig. 61 shows the working drawing for the front view of a Swedish foot power loom. The parts are all so definitely dimensioned that further description is unnecessary. Fig. 62 shows a working drawing for the side view of the same loom, and Fig. 63 shows the drawings in detail for the various parts assembled and named in the completed loom (Fig. 64).

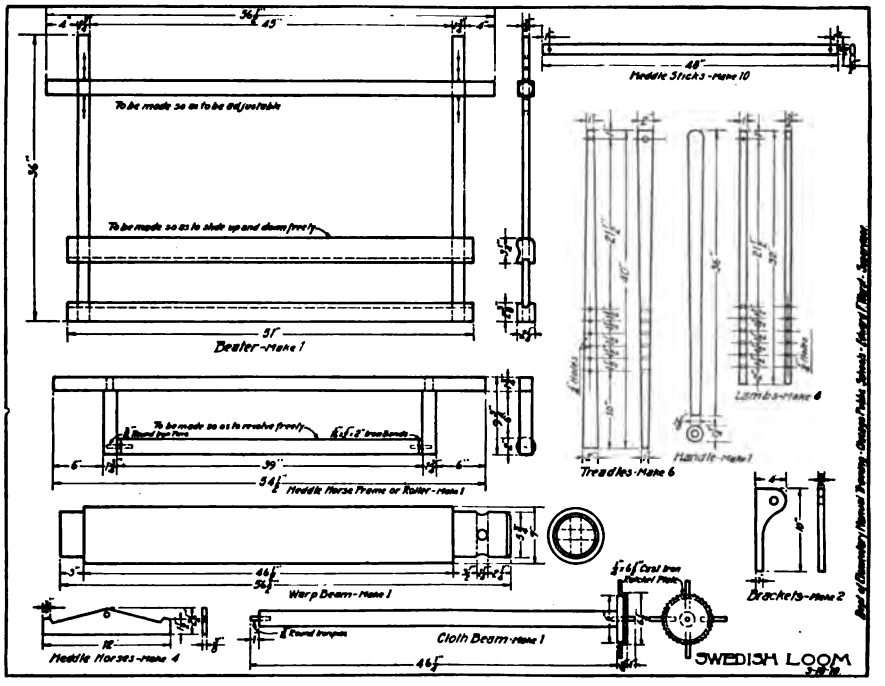

Fig. 63.

While several kinds of wood may be used in the construction of the loom, maple has been found the best. Norway pine and even poplar have been used. When maple is used, yellow pine may be used for the warp beam and treadles and for other parts not included in the actual frame of the loom.

While the loom as given will weave an article forty-five inches in width, it is not necessary to construct the loom quite so large. A large loom, however,

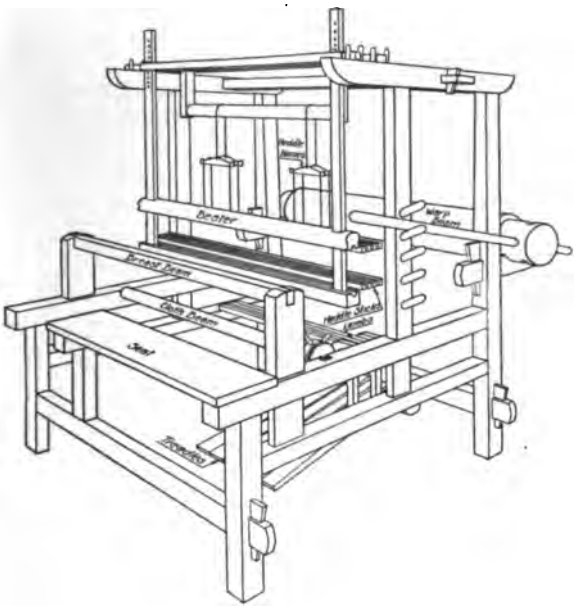

Fig. 64.

is more satisfactory than a small one, because of the fact that a variety of widths may be woven on it. The small loom is too limited in width.

The drawings may be used as given, or if so desired, changes may be made so as to produce a small loom and perhaps a more simple construction worked out.

The loom recommended is one that may be used for pattern weaving. The working drawings provide for six treadles and four harnesses. It will also be observed that the lambs are used to aid in the pattern weaving. Fig. 64 shows the completed loom, each part being named.

The ratchet need not necessarily be of cast iron. It may be made of hard wood.

The loom is best finished by giving all the wood parts a coat of shellac. Care should be exercised in not having the shellac too thick. Two coats of thin shellac are better than one coat of the thick.

The entire construction is that of a knock down type which makes it possible to store away the loom in a comparatively small space at any time. Only a few minutes are consumed in setting up or taking down the loom.

Fig. 65.

To the inventive mind, the construction of the loom given will lead to other looms more simple in their construction and looms having such dimensions as will suit the space they are to occupy. This project, besides being a practical weaving project, is an excellent woodworking exercise. The

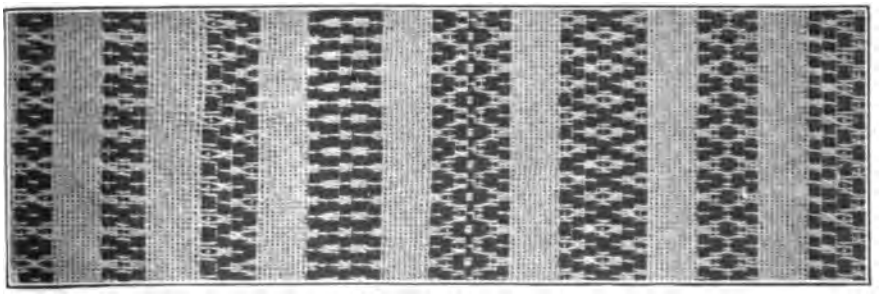

Fig. 66.

woodworking students, even if not interested in weaving, may make the loom for the studio with advantage to themselves.

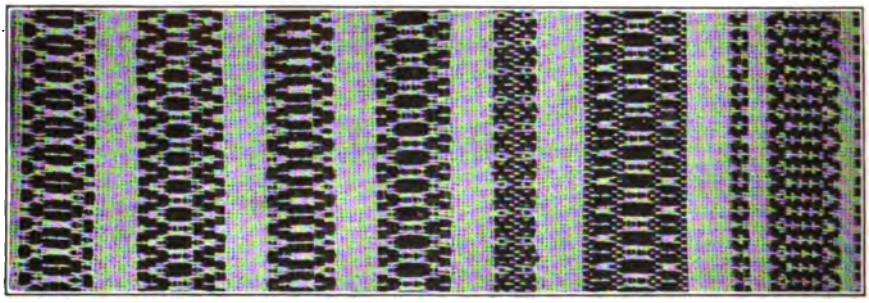

Fig. 67.

Fig. 65 shows a simple threading for a four harness loom and Figs. 66 and 67 show a few of the combinations which may be worked out in the form of borders.

Fig. 68.

Fig. 68 shows another simple threading and Figs. 69 and 70 show a number of combinations which may be worked out.

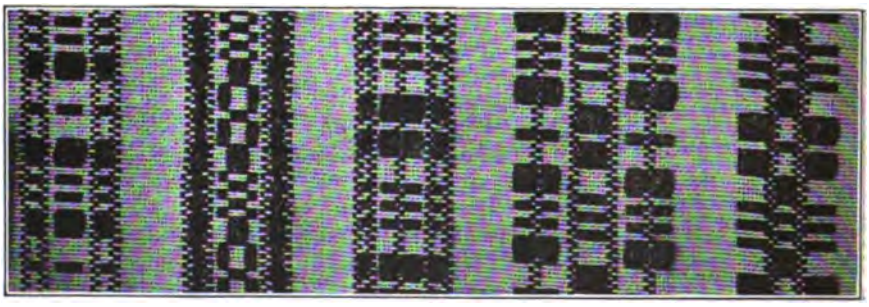

Fig. 69.

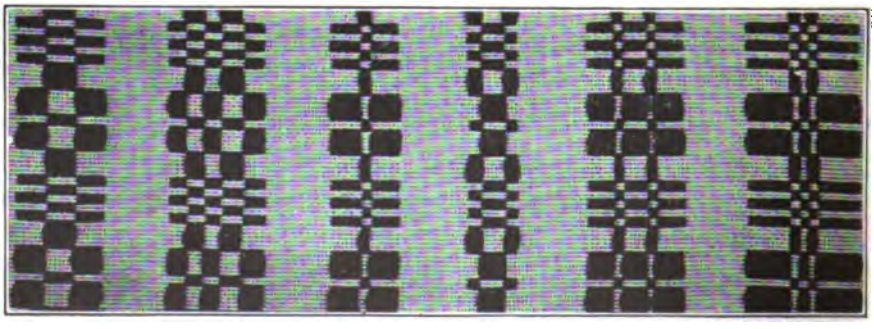

Fig. 70.

Fig. 71.

Fig. 72.

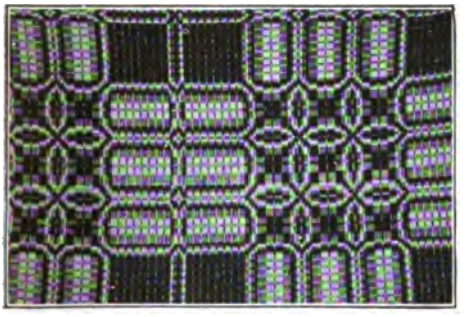

Fig. 73.

Figs. 71, 72 and 73 show designs which have been woven on a loom as described. The casual observer is apt to look upon weaving as a mere mechanical process—offering little or no opportunity for originality. This is not true for the work is full of possibilities. Most beautiful table runners, pillow tops, curtains, couch covers, counterpanes, and numerous other articles for home furnishings may be woven by boys and girls.

Reference—

Foot Power Loom Weaving, by Worst, The Bruce Publishing Co., Milwaukee.

TELEPHONE BRACKET *

38. In the office, shop or home one usually finds the telephone on a table or desk. It is, however, much in the way, especially on a desk and there is danger of its falling off when books or papers are shifted about.

The commercial extension bracket for holding the telephone is very convenient and is used extensively. It may be attached to the wall or directly to the desk. An excellent project is afforded, however, by constructing the bracket in the shop and using wood for the extension arms as shown in the illustration. This one closes to about 12 inches and extends to 36 inches.

The general dimensions of the bracket are indicated on the drawing, so it will be quite easy to make a bill of material for this size.

While several kinds of wood may be used for the extension arms, hard maple is suggested. It is necessary to have soft strap iron for the clamps,

* By F. B. McElroy, Instructor of Industrial Arts, Washington School, Indianapolis, Ind.

brass tubing, soft rod for the end supports, machine bolts or rivets and washers. The circular disc may be made of poplar.

Conditions under which the telephone is used will govern the plan of the bracket. To decide on the reach of the bracket, measure the distance from the supporting place on wall or desk to the point where it is desired to use the telephone. With this distance in mind and comparing it with the bracket illustrated you can determine the lengths of the arms. Other points to decide are:

Conditions under which the telephone is used will govern the plan of the distance between the holes for the bolts? Why? Also, should the wood strips be heavier?

How should the wood portions be finished? Will they match other furniture in color or kind of finish?

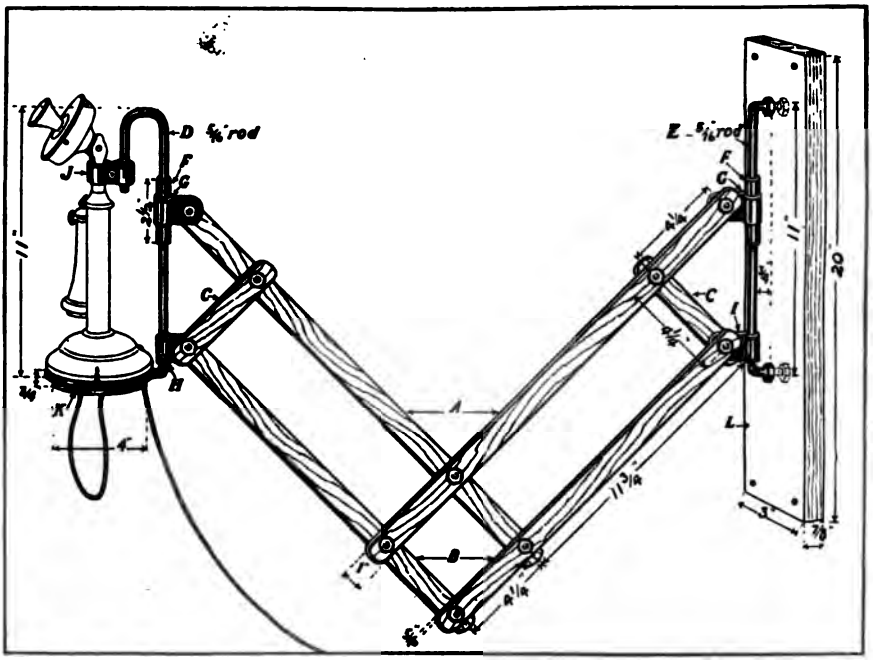

Fig. 74.

Instead of iron fittings, would it be better to use brass rods and clamps? Why?

Will it be necessary to have other means of supporting the bracket than by a board as shown?

Would it be more desirable to use rivets instead of machine bolts?

Make a mechanical drawing of the project. It should show the bracket assembled as well as each of the details. If you have changed sizes of any of the parts, make a bill of material in accordance with your drawings.

All dimensions on the drawing given above show finished sizes. From your stock, make the extension arms consisting of parts **A, B, C.** Be sure the strips are brought to correct sizes. It is important that the holes in the strips are accurately measured off and bored. Why?

Part D is rather difficult to make on account of the curves; however, in a metal vise they can be properly adjusted. Measure off on the $\frac{1}{4}$ inch rod the positions of the curves. Make the 4-inch circle first, then crook the right angle turn, place the tube, part F, on the rod and make the turns at the top. Drill hole for $\frac{3}{32}$ inch rivet which fastens lower front clamp.

Part E is quite simple, except you must remember to place the tube on the rod before making the last angle turn, and the cutting of the threads requires careful work. Use a $\frac{1}{4}$ inch No. 18 die, which cuts a thread for a standard machine nut.

The tubes, parts F and F, may be purchased in proper size or made from sheet metal and they may be put on after curves are made in the rods. What gauge metal would you use?

Parts G and G, the top clamps, fit quite securely around the tubes to hold the tubes as they slide up and down parts D and E. Parts H and I are alike, except that part H is riveted to part D as shown. Why? This is not necessary for part I. Why? These clamps are made of $1\frac{1}{4}$ inch strap iron.

Part J consists really of three parts, the two clamps and a bolt. One strip of $\frac{5}{8}$ inch strap iron may be formed to the proper curves and then sawed for the two pieces. Drill holes for the bolt.

The circular disc, part K, should fit tightly in the circle on the rod. It has a countersunk hole in the center for the screw which fastens it to the telephone.

Part L may be made of proper size to fit the place where it is to be screwed for supporting the bracket. The wood used for it should be of a kind that will not split easily.

In finishing the wood parts, bear in mind your original plan for the project, using natural or stained finish as desired.

The problem of assembling is not difficult, but very interesting. Join the extension arms with machine bolts, using two washers with each bolt. Should all the bolts be the same length? Place part E in part L and fasten the latter to the wall. Fix in position on part D the two front clamps and fasten to arms. Connect arms to part E with the rear clamps. The wood disc should now be fastened to the telephone by removing the screw in the base of the telephone and, with a longer screw of the same number, securing the disc to it. Put the telephone in place on the front support, making sure that the disc fits properly in the circle provided for it and fasten with part J.

The plan followed in this project may be applied in many other useful things. In the bathroom or at the side of dressing table or dresser in bedroom, such a bracket may be placed to support a mirror. A copyholder for use of the stenographer could be constructed in much the same way. Such a bracket would, when properly suspended from the wall, make an excellent support for a reading lamp. A folding gate for the porch is another good problem. In what other ways could one make use of this extensive plan?

The telephone bracket is one of the conveniences in connection with the telephone industry. This industry, on account of the service afforded in talking from one place to another, is of greatest importance to the country. The manufacturing of all equipment and supplies necessary for the industry, naturally covers many lines of work and large numbers of people are thus employed. It requires different tradesmen to erect the lines and plants or exchanges, to keep everything in working order, and thousands are needed to operate the systems.

On account of the several trades in the manufacturing, erection and operation divisions of this industry, a careful study should be made of each division.

Look up all references given and visit plants, if possible, to inspect the making of the apparatus or the use of it.

When and by whom was the telephone invented? Do telephones differ? In what ways? What is one of the latest improvements on the telephone? Have you heard of any recent experiments to further improve or enlarge the use of the telephone? Are there other machines which work on the same principle as the telephone? Are telephone and telegraph systems similar? How?

Make a list of all the trades which you find are connected with this industry. Refer to the index of this book so as to locate the explanation of each trade in this industry which produces some part or piece of apparatus.

If this project should be made in large numbers for sale, what methods in constructing it would differ from those used by you? Why? Figuring your time at 40 cents per hour, and including cost of all material, what is the cost of the bracket you made? If sold at 25 per cent profit, what would be the selling price?

References—

The New International Encyclopedia, Vol. 22.
The Electric Telephone, by George B. Prescott.
Telephony, by Samuel G. McMeen and Kempster B. Millen, American Correspondence School, Chicago.

CARD INDEX BOX *

89. The card index method of concentrating information of one form or another is the modern idea; it is convenient, occupies little space, and gives one easy access to information often referred to. It has a place in the business man's office, in the school room, in the home, and in numerous other places. The library shows a splendid use of the card index system.

Standard cards are 3″x5″ and 4″x6″, the smaller card being almost universally used. The dimensions given on these drawings are for a box designed to contain 3″x5″ cards. The index cards are 3⅜″x5″, the added ⅜″ being for indexing. These cards are usually of the form shown in C, Fig. 75, the necessary information for the proper use of them being placed at D.

Materials listed below will make a box large enough to hold a large number of cards:

For the box proper:

1 pc. chip board, 8½″x10¾″. (Any fairly heavy cardboard will answer.)
1 pc. covering material, 3¾″x12¼″.
1 pc. covering material, 3¼″x5″.
4 pcs. binding cloth, 1″x2⅝″. (This may be the gummed binding cloth that can be purchased in rolls.)
1 pc. paper or covering material, 2¾″x5″.

For the lid:

1 pc. chip board, 5″x7¼″.
1 pc. covering material, 2″x12¼″.
1 pc. covering material, 3¾″x5″.
4 pcs. binding cloth, ⅞″x1¼″.

* By J. J. Ritter, Director of Industrial Work, Ft. Wayne, Ind.

For the insert:

1 pc. chip board, 3"x16½".

1 pc. covering material, 1½"x17".

For the hinge:

1 pc. binding cloth, 1¼"x2⅞", or 1¼"x5". (Double for additional strength.)

Having determined the size of the card to be used, the capacity of the box simply depends upon the width of the box. The width should be sufficient to make a substantial box as well as one of good proportions. The covering material may be of any desired material and color, preferably cloth (binder's cloth) because of its durability.

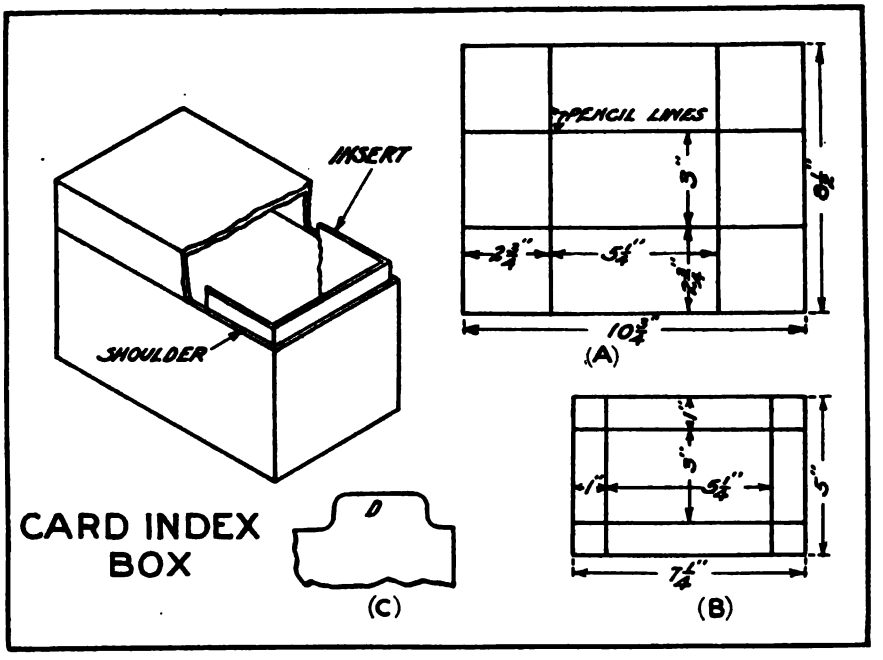

Fig. 75.

The lay-out or pattern on the material itself will be sufficient, once the size of the box is known, as the material must be measured, marked and cut accurately. It is well, however, to have at least a dimensioned sketch of the box, so that the sizes of all materials may be planned conveniently.

It is assumed that the student has had previous experience leading up to such a problem as this; experience in the use of materials, scoring material so that it will not "break" when folded, removal of corners of cardboard, fitting corners of covering material, etc., so that an explanation of these details is not necessary in this article.

The procedure in constructing and assembling the box must be definite and carried through without delay. The pasting process is simple enough, but the

stretching of the cloth must be taken into account. By keeping a good stretch on this cloth after the paste has been applied to it, the shrinkage, as drying takes place, will usually produce a smooth, neat job.

Lay out cardboard as shown in A, Fig. 75.

Lay out cardboard as shown in B, Fig. 75.

Remove corners, score on outside, fold, and attach binding cloth at the corners.

Attach 3¾"x12¼" covering material to the front and ends of the box proper; paste extras to back, inside and bottom.

Attach 2"x12¼" covering material to the front and ends of the lid; paste extras to back, inside and top.

Make insert to fit the box, using 1¼"x2⅞" binding cloth at the joint. This insert is higher than the box proper and thus a shoulder is formed. This construction provides a means of stiffening the box, properly seating the lid, and giving the lid a resting place.

Caution: Measure the inside of the box carefully before making the insert, as this should be a close fit.

Cover both sides of top of insert with 1½"x17" covering material.

Paste the insert into the box; be sure to paste all around at the top.

Attach hinge to outside of box and lid.

Cover top and back of lid with 3¾"x5" covering material.

Cover back of box with 3¼"x5" covering material; turn extra and paste to bottom.

Attach 3¾"x12¼" covering material to the front and ends of the lid; paste

Opportunity for originality is offered in the size of the box, the finish (color of covering material), its use, and in the design of the index cards. See C, Fig. 75. When a box of great capacity is desired, the lid probably should not be hinged.

This box, in its materials and construction, is typical of work of this kind (box making), and, once having gotten the idea clearly in mind, the student can easily adapt this experience to other problems involving similar materials, principles, and methods.

References—

Paper and Cardboard Construction, by Buxton and Curran, The Manual Arts Press, Peoria, Ill.

Cardboard Construction, by Trybom, Milton Bradley Co.

A STUDENT NEWSPAPER *

40. One of the greatest socializing agencies is the newspaper. It informs us of happenings of general interest, the opinions and ideas of others, and inspires in us a responsibility in the problems of the nation or community. Coming as the successor of the heralds and town criers of earlier times, it has become a vital factor in establishing civic cooperation, molding public opinion, and promoting modern ideas. Today every community, and nearly every organization in all the fields of endeavor, has a newspaper devoted to its interest.

With the introduction of printing in the schools, the small student newspaper has been made possible, and it fills a need in the social and community life of the school.

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* By Ralph W. Polk, Director Vocational Instruction, City Schools, St. Joseph, Mo.

The student paper should represent and serve the school, contain the news of the school, voice the ideas and opinions of the students, uphold the school in the community, and stimulate its readers to better thought and action.

It should be a small paper, clearly within the scope of the equipment and working ability of the printing class. Small copies issued at intervals of two, four or six weeks, are better than larger ones issued less often. The former will prove of greater interest to the readers and will not interfere with systematic work in the printing plant.

The paper stock on which most newspapers are printed is a rough, soft finish, uncolored paper, known as "print paper." It is of poor quality, easily torn, and soon discolors after exposure to the light. Small publications are often printed on a better quality of white paper, known as "machine finish book paper." Machine finish paper is recommended for the student newspaper. If print paper is used, a thinner printing ink, called "news ink," should be used for printing, but, if machine finish paper is used, a good grade of "book" or "job ink" should be used.

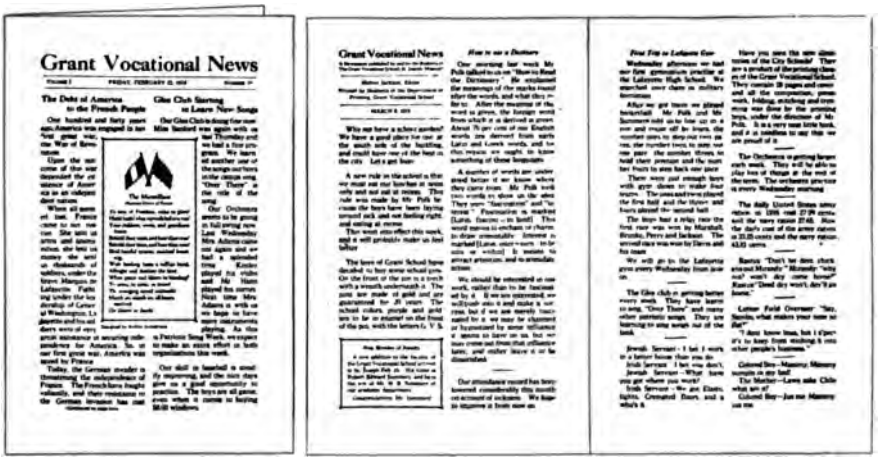
Grant Vocational News

Fig. 76.

The standard width of a newspaper column is 13 picas or 2 1/6 inches. Pages vary from five to eight columns in width, and the issue from four pages up. It is best to plan the student paper with two standard columns to the page. This will allow the printing of two pages together on a 10x15 or 12x18 Gordon press.

If double-column pages are planned, the correct column length will be 45 picas. Nonpareil column rules may be used between columns, as in the larger papers, but a better method is to place the columns one pica apart, eliminating the rules. In this case, the page forms would be 27x46 picas, allowing a nonpareil slug at the top and bottom of the page. The page size for the paper would be 6x9 inches, and the stock would be cut 12x9 inches to allow for the double page.

The type used for the body of the paper should be either 8 point or 10 point, according to the size available in the shop and the amount of time allowed for the composition. Eight point type, leaded, will average 736 words, and 10 point,

leaded, will average 512 words to the page. If type is especially chosen for the paper, the Century Oldstyle series is excellent for the body matter, and New Caslon type for the headings. A number of other styles are also appropriate.

A "dummy," or general plan of the paper, should be made before printing. This will give a clearer idea of how the paper will appear, and will serve as a guide in making up the pages.

The main heading on the first page should be set in a large, bold type. The date line below this head should contain the volume and issue numbers, the date, and the price per issue, if desired. This line should be set in capitals of body type, one size smaller than the text. Headlines should be one or two sizes larger than the text, in a bolder style of type.

In the accompanying illustration, 30 point New Caslon is used for the main heading, "Grant Vocational News," 12 point New Caslon is used for headlines, and 10 point Century Oldstyle for the body matter.

The most important articles, preferably current news, should occupy the first page. If this matter does not fill the page, small paragraphs of general interest may be placed at the bottom of the columns. If either of the main articles run past the first page, the lines "Continued on page —" and "Continued from page —" should be set in small type and placed at the close of the first page column, and at the beginning of the "run-over," respectively. Also, the heading must be repeated above the run-over.

The second page of a four-page paper is commonly known as the editorial page. At the head of the first column is the position for the subhead. In this, the name of the paper, editorial staff, date, and sometimes the subscription rate, appear. Editorial items follow the subhead.

The order of articles for the third and fourth pages is not clearly defined, and may be arranged to suit the wishes of the editors or printers.

As each article is composed, it should be proofed separately, and corrected. The page forms can then be made up from the corrected articles.

In locking the forms for the press, nine picas of space should be left between the two pages, for the inner margins. Pages 4 and 1 are locked together, likewise 2 and 3. The first double form should be centered in the chase and the second can then be locked in the same position, requiring no further registering on the press after the guides are once set. After one side has been printed, enough time should be allowed for the ink to dry before printing the second form.

When the printing has been completed and the sheets are dry, they may be folded once, with the first page on the outside. This completes the making of the newspaper.

The various processes followed in the printing of a school paper may be studied further with profit to the student. It will be well to make a study of headlines, as they appear in current publications. There are many styles of headlines, and a careful analysis will reveal the most forceful ones. Accuracy in reading and correcting proofs may also be carried beyond the work of the newspaper, and practical exercises in this phase of the work will be very profitable.

Every student should visit the newspaper plants of his locality, and learn what he can by close observation of the practical work. This will give him many ideas, and will better acquaint him with the work and its responsibilities and opportunities.

Newspaper and magazine publishing is one of the largest industries in America. A great many opportunities are offered in this line of work to young

people who understand something of the basic principles involved. The student paper brings out some of these.

In large newspaper offices, linotype machines are used in the composition of the body type, replacing hand composition. However, the knowledge of capitalization, indentions, correct division, and justification are essential to the operator of the linotype.

Hand compositors set the larger headlines, and the display part of the advertisements. Make-up men arrange the matter and make up the pages in much the same manner as is done on the student paper.

An additional operation enters into the printing of some of the big newspapers. The sheets are not printed directly from type, but the page forms are stereotyped, and the printing is done from the plates obtained by this process. The plates are curved to fit cylinders of high speed rotary presses, and the paper is fed into them from large rolls. After leaving the inked plates, the web of paper is cut and folded automatically, leaving the press as complete finished copies.

In nearly all the operations of making a large newspaper, the principles exercised in the school publication are carried out on a larger scale, and this experience in the school is a first step toward the publishing industry.

References—

Manual of Style, University of Chicago.

Vocational Printing, by Ralph W. Polk, Guy M. Jones Co., Indianapolis. Chapter XI (Proof-Reading); Chapter XII (Composition); Chapter XIV (Presswork).

The Typography of Advertisements, by F. J. Trezise, The Inland Printer Co., Chicago.

BENCH BRUSH *

41. There is always use in the shop for a bench brush. Not only in the shop but in every walk of life, the brush has become a permanent necessity. Brush-making provides good projects for the shop, introducing several separate lines of work in the making of one project. There is hardly any limit to the different sizes, kinds and styles of brushes that may be made.

One of the first things to decide is the use to be made of the brush when finished. This largely determines the kind of materials, size, shape and finish to be used.

Close grained wood is best for the handle, owing to the fact that so many holes are bored in one grain line, although other woods may be used successfully. Gum, poplar and similar woods will be found very good for this work. The brush itself may be made of several different materials. Bristles are best, horse hair ranks next, while for the cheaper qualities of brushes fibers may be used.

The wire for pulling and securing bristles may be either steel or copper. For work where the brush does not come in contact with water, steel wire will be found stronger and more economical.

A mechanical drawing of the brush should show details and also the assembled and finished project. A bill of materials should be made from the draw-

* By Frank M. Treat, Instructor of Industrial Arts, Indiana University, Bloomington, Indiana.

Assembling, after construction is finished, is a very simple matter with only showing reduction in the cost per brush when a large number are made at one time.

The most difficult part in the making of the brush is the accurate boring of the holes into which the fiber or hair is drawn. This is best solved by the making of a jig. The angle, depth, and position of the holes are shown by A and B in Fig. 77. A complete drawing of the jig for boring the holes should be made showing the position, size and angle of the holes. The jig can be made of hard wood and, with careful handling, will last for some time, but to make a permanent jig, it is better to use a metal plate, which gives a project for use of metal working machines. It is essential that all holes in the jig are accurately measured and bored. Make the plate for a guide to bore the holes, using about ⅜" metal. Using a ¼" drill, bore through the plate at the angles shown in Fig. 77. Arrange a system of cleats or clamps to hold the brush back securely in place while being bored.

The boring of the holes for pulling the bristles can be made much more easily with a power boring machine, using no jig and boring each hole in a free hand manner. This can be accomplished successfully only by pupils advanced in the

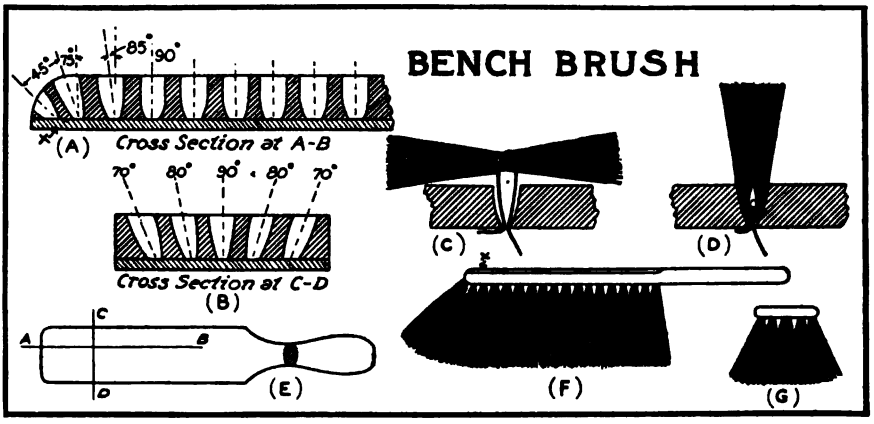

Fig. 77.

use of machines and those who are very accurate in their estimate of angles and distances.

The handle and brush back should be shaped to the desired form, and about ⅛" cut away from the back as illustrated to cover the wire used in pulling the fiber into the brush. The back is to be placed in the jig, secured with clamps and holes bored to the depth shown in the drawing, Fig. 77. The brush is next ready for pulling.

Take the materials to be used and cut into lengths equal to twice the length of the exposed fiber in a finished brush. Start a wire loop through a hole and pull the brush material half way through the loop as shown by C in Fig. 77. Draw up the wire until the material is firmly seated into the curved bottom of the hole as shown by D in Fig. 77. After completely filling the brush in this manner see that all ends of the wire are firmly fastened.

Assembling, after construction is finished, is a very simple matter with only the back to fit and fasten. Make sure that a good, smooth fit is secured and that the method used does not ruin the back cover.

Finishing gives an opportunity for the student to select color and finish to suit his ideas. Usually, a single color should be used, and the surface should be smooth before the finish is applied.

The general plan used in making the bench brush may be applied in the making of many kinds and styles of brushes for special conditions. Nearly every trade calls for some style of brush, such as shoe brushes, clothes brushes, domestic science brushes and many others too numerous to be given in detail at this time. This is left entirely to the individual student to work out with the aid of the instructor.

The manufacture of brushes and their application to every walk of life has been greatly developed in the last few years.

Look up references on the brush. Visit factories where brushes and brooms are made. The latter is an allied industry. The principal part of the information in regard to the making, history and manufacture of brushes must be learned from those who are in the business, for very little has been written on the subject.

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Brushes and Brooms, a magazine.

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